JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CVII. JUNE, 1879. No. 6.

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PEAUCELLIER'S COMPOUND COMPASS AND OTHER LINKAGES.

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The writer, in order to avoid the use of cumbersome beam compasses, having designed for the use of his students a compound compass, upon the principles first enunciated by Peaucellier, and not being aware of the existence of specific directions for the construction of a similar apparatus, believes that the following directions may be of use to the engineering profession, as being sufficiently explicit to admit of the construction of curve rulers by those able to follow the simplest mathematical work.

The theory cannot be set forth in a more interesting manner than in the subjoined translation of a paper written by the inventor, and published in the *Nouvelles Annales de Mathématiques*, Deuxieme Série, t. xii, p. 71. 1873.

NOTE UPON A QUESTION OF COMPASS GEOMETRY.

By M. PEAUCELLIER.

(This problem, dated 1864, was solved at that time, as indicated by a letter in the *Nouvelles Annales de Mathématiques*, 2e série, t. iii, p. 414.)

We shall give the name of Compound Compass to any articulated system whatever of rigid pieces in complete connection (*a liaison complète*). We know that this name is generally applied to every assemblage of bodies in such a manner that the movement of any point whatever causes the movement of all the others.

The pantograph, the parallelogram of Watt, etc., are such assemblages, and may be considered as compound compasses.

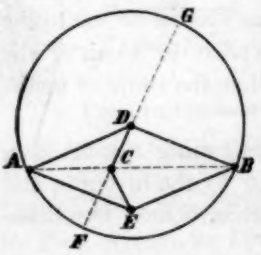
Apparatuses of this kind possess the valuable advantage of requiring very small forces to put them in motion, and their displacements are continuous and perfectly regular, by reason of the possibility of completely suppressing all play in the articulations.

They have neither irregularities nor "lost motion," to speak technically.

These diverse properties specially recommend them to the constructor of instruments of precision, and we shall adopt them exclusively for the object that we have in view, that is to say, the mechanical tracing of plane curves.

The line that starts from any point whatever, guided by a combination of articulated pieces, is necessarily algebraical. Reciprocally one perceives that all algebraical curves can be generated by a properly arranged articulated system, because one will always have at command a sufficient number of variable elements, radii and centres of rotation to be able to satisfy the equations expressing the identity between the given curve and the described one.

Fig. 1.



In what follows, we will limit ourselves to compound compasses tracing the best known lines, the straight line, the circle of any radius, the conic sections, and lastly conchoids and cissoids.

We shall present the result of our researches in a synthetical form, the analytical processes which have guided us in the most interesting part of this work, that relative to the straight line being very complicated, and not being, in fact, a method of investigation sufficiently methodical.

Lemma.—Any point whatever, *C*, Fig. 1, taken upon the diagonal of a lozenge, divides it into two segments of which the product $\overline{AC} \times \overline{CB}$ is equal to the difference $\overline{AD}^2 - \overline{CD}^2$ between the squares

constructed upon the side of the lozenge and upon the distance $\overline{CD}$ of the point considered from the extremities of the other diagonal.

Prolong $\overline{CD}$ till it cuts in F and G the circle described from the point D as a centre with the radius $\overline{DA}$.

We have

$$\overline{AC} \times \overline{BC} = \overline{CF} \times \overline{CG} = (\overline{AD} - \overline{CD})(\overline{AD} + \overline{CD})$$
$$= \overline{RD}^2 - \overline{CD}^2$$

This remarkably simple demonstration has been given to us by M. Mannheim.

It follows then that if one supposes that the figure *EADBECD* represents an assemblage of rigid rods articulated at their extremities, and that the point C remains fixed, the opposite extremities, A and B, will describe reciprocal curves. This combination will form the essential organ of the divers compound compasses that we shall have to examine.

1st. The reciprocal of a straight line being a circle passing through the pole, if the point B (Figs. 2 and 3) is forced to move in the perimeter of a circle passing through the centre of articulation C, the movement of the point A will be rectilinear. It will therefore suffice, in order to generate a straight line, to introduce in the mechanism

Fig. 2.

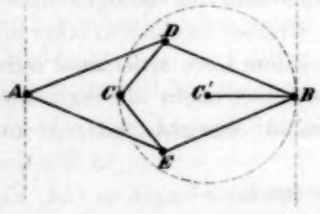
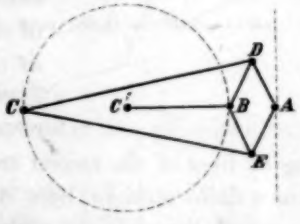


Fig. 3.



EADBECD a new fixed centre, C', to which one fastens the point B, the link $\overline{C'B}$ being equal in length to the distance $\overline{CC'}$ between the fixed centres.

What precedes constitutes a rigorous solution of the problem stated by Watt. It is simple enough to be advantageously employed in certain machines of long stroke.

Mr. Mannheim, in 1867, made it the subject of a communication to the Société Philomathique of Paris

2d. If the circle described by the vertex B does not pass through

the fixed centre C, the opposite vertex A describes a circle whose radius is represented by the expression

$$R = \frac{(a^2 - b^2)r}{r_2 - d^2}$$

in which one designates by a the side of the lozenge $\overline{AD}$; b the bridle rod $\overline{CD}$; r the radius $\overline{C'B}$; d the distance between the centres CC'.

If $r = d$ we have $R = \infty$ which corresponds to the case of a straight line.

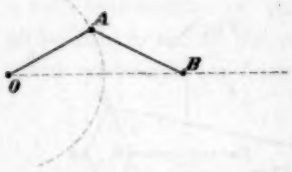
This combination of articulated pieces will then permit, if we vary one of the elements, for example the distance CC', the tracing of arcs of circles of every curvature in a continuous manner.

Designers know that this operation, apparently so simple, is not less complicated than the tracing of any geometric curve whatever, when it happens to be a curve surpassing the extreme limits of the beam compass.

3d. Let us now consider the conic sections.

We know there exists an infinity of theorems leading to their determination by means of the straight line and the circle, if successive points of these lines are given. Of the articulated systems coming in question, permitting so to say, the materializing of every combination of straight lines and of circles, without recourse to other organs of transmission, have articulated rods, we foresee that there ought to exist an infinity of compound compasses adapted to the tracing of lines of the second order.

Fig. 4.



Thus a finite straight line, AB, of the same length as OA, Fig. 4, being moved, for example, with its extremities in the circumference of a circle, and upon one of its diameters, $\overline{OB}$, each point of the movable line will describe an ellipse. This theorem furnishes a very simple means of constructing an elliptic compass, since we are able to guide the straight line $\overline{AB}$, by its extremities as the data of the problem require.

But there is a more general solution, capable, by means of the same combination of lines, of describing all the conic sections without distinction.

The polar equation of these curves is

$$\rho = \frac{p}{1 + \varepsilon \cos. \omega}$$

and represents ellipses, parabolas or hyperbolas, according as $\varepsilon < 1$; $\varepsilon = 1$ or $\varepsilon > 1$.

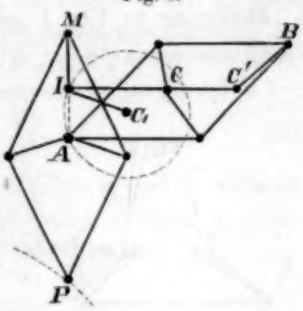
If we consider the reciprocal curve of the preceding, we will have for the equation

$$\rho^1 = \frac{k^2 (1 + \varepsilon \cos. \omega)}{p}$$

k being a constant. It is a limaçon de Pascal, of which we shall describe the mechanical generation.

For this, let us return to the compass relating to the straight line, to which we will add the bridle rod, $\overline{C_1 I}$, Fig. 5, where the straight line described by A cuts the line of centres CC'. If we fix the point C_1 as well as the vertex A, and make $C_1 I = C_1 A$, and let all the other points of the figure remain free, it is apparent that any point M of the perpendicular IM to CC' will describe a limaçon de Pascal. Of which the equation will be

Fig. 5.



$$\rho^1 = 2 \overline{C_1 I} \cos. \omega + IM$$

Its reciprocal relatively to A is a conic.

We shall obtain this latter curve by connecting the point M to the free vertex of an articulated system whose fixed centre is A.

This point will become the focus of the conic of which $\overline{AC}$ will be the direction of the principal axis, and which will be

$$\left.\begin{array}{l}\text{An ellipse,}\\ \text{A parabola,}\\ \text{A hyperbola,}\end{array}\right\} \text{if } \frac{IM}{2C_1 I} \left\{\begin{array}{l}< 1\\ = 1\\ > 1\end{array}\right.$$

It is besides evident that by giving to IM and to $C_1 I$ convenient values it will be possible to trace with the same compound compass all the curves of the second degree.

Conchoids of the Circle and of the Straight Line, Cissoid, etc.

We have just seen how one is able to arrange for tracing the conchoid of the circle, or limaçon de Pascal; by modifying the combination relative to this curve in a similar manner to that pursued for the conics we shall generate the conchoid of the straight line. We find in

the same manner the combinations suitable for the lemniscata, but they are for the most part very complicated. We shall content ourselves, in closing this short summary, by indicating the compass for the cissoid, which is extremely simple. The centre of articulation of the links $\overline{CD}$ $\overline{CE}$ (Fig. 6) is forced to move in circle passing through the fixed vertex A of the lozenge, whose diameter is equal to $\sqrt{b^2 - a^2}$.

As before, b designating the length CD and a the length AD.

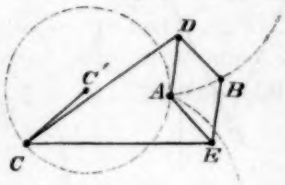
The opposite vertex B under these conditions will trace the cissoid, as is easy to see by forming the equation of the described curve.—*End of translation.*

This translation is made with the desire that the fortunate inventor of this remarkable linkage be awarded by English readers the credit justly his due; not only as an inventor but as a mathematician capable of understanding and discussing his invention in an able manner.

Referring to Fig. 1 and, for the sake of brevity, designating the radii vectores AC by ρ^1, BC by ρ and the constant $\overline{AD}^2 - \overline{CD}^2 = a^2 - b^2$ by m^2, called the modulus of the linkage, we have

$$\rho\rho^1 = m^2 \qquad (1)$$

Fig. 6.



Referring to Figs. 2 and 3, Section 1, we see that the fixed centre C', midway between B and C and the radius bar $C'B$, forces the vertex B to move in the perimeter of a circle passing through the pole C (fixed point), the prime radius of which is its diameter. This gives

$$\rho = 2\, r \cos.\, a$$

in which $r = CC' = C'B$ and $a =$ the angle through which the point B is moved with respect to the fixed line ACB. Substituting this value in Equation (1), we have

$$\rho^1 = \frac{m^2}{2\ r\ \cos.\ a} = \frac{m^2}{2r} \sec.\ a \qquad (2)$$

Which is the polar equation of a straight line at right angles to the prime radius ABC, and we see that the point A will describe a straight line.

The form of cell outlined in Fig. 2 is commonly called a negative cell, and that in Fig. 3 a positive cell.

Referring to Section 2, and using the notation there given, we have for any position of C' between B and C

$$\rho^2 - 2\,d\,\rho\,\cos.\,a = r^2 - d^2$$

$$\rho = d\,\cos.\,a \pm \sqrt{r^2 - d^2 \sin.^2 a} \qquad (3)$$

Substituting for ρ its value $\frac{m^2}{\rho^1}$ we have

$$\frac{m^4}{\rho^{12}} - \frac{2\,d\,m^2}{\rho^1}\,\cos.\,a = r^2 - d^2 \text{ and reducing}$$

$$\rho^1 = -\frac{m^2\,d}{r^2-d^2}\,\cos.\,a \pm \sqrt{\left(\frac{m^2\,r}{r^2-d^2}\right)^2 - \left(\frac{m^2\,d}{r^2-d^2}\right)^2 \sin.\,a} \qquad (4)$$

If in this equation we place

$$D = \frac{m^2 d}{r^2-d^2} \text{ and } R = \frac{m^2 r}{r^2-d^2}$$

Equation (4) becomes

$$\rho^1 = D\,\cos.\,a \pm \sqrt{R^2 - D\ \sin.^2 a} \qquad (5)$$

and we observe that Equations (3) and (5) are similar; therefore while the vertex B describes an arc of a circle as stated with the radius r and centres at a distance, d, from the pole C, the vertex A will describe an arc of a circle whose centre is on the prime radius at a distance, D, $= \frac{m^2 d}{r^2-d^2}$ from the pole C with a radius

$$R = \frac{m^2 r}{r^2-d^2} = \frac{(a^2-b^2)r}{r^2-d^2} \qquad (6)$$

If we make the distance between B and C (Figs. 2 and 3) constant and $= 2\ e$, and denote the distance of the point C^1 from a point bisecting the line BC by x, we can simplify this equation.

Let $d = e \pm x$

" $r = e \mp x$

We have $R = \frac{m^2 r}{r^2-d^2} = -\frac{m^2(e-x)}{4\,e\,x}$ or $= \frac{m^2(e+x)}{4\,e\,x}$

Still further reducing, we have for the value of x

$$+\,x = \frac{m^2}{\frac{m^2}{e} + 4\,R} \qquad (7)$$

$$\text{or } -\,x = \frac{m^2}{\frac{m^2}{e} - 4\,R} \qquad (8)$$

since in the latter case R is of the contrary sign.

We have now a ready means of computing the distance x to the right or left of the central point of the line BC, in order to describe an arc of any required radius, R.

When x is $+$, *i. e.*, moved to the right, the arc is convex to the pole C, and Equation (7) should be used; when $x = 0$ we have an arc of infinite radius, a straight line; when x is $-$, *i. e.*, moved to the left, the arc is concave to the pole C, and Equation (8) should be used in computing the radius.

The compound compass shown in Fig. 7 is adapted to drawing arcs of a little over 3 feet in length.

The construction will, in the light of previous explanations, be readily understood; in it we have taken $a = 12$ inches

$$b = 8 \quad \text{“}$$
$$2e = 12 \quad \text{“}$$
$$\text{giving } m^2 = 144 - 64 = 80$$

This will be found a most convenient size for the ordinary purposes of the draughtsman.

At C^1 is a split joint, such as is used for proportional dividers, and the vertex B is steadied by means of a hole and pin while the joint is being adjusted at any required distance from C^1, this joint sliding in the slots in the radius bar C^1B and the ruler CB. A scale reading to hundredths of an inch is laid off from the central point C^1 three inches both ways.

The better method of locating the mid point C^1 is to adjust it tentatively until the vertex A describes a perfectly straight line. The following table of values of x for circles of radii between 10 and 120 inches has been computed by means of Formulæ (7) and (8), which reduce to

$$\pm x = \frac{60}{10 \pm 3R} \qquad (9)$$

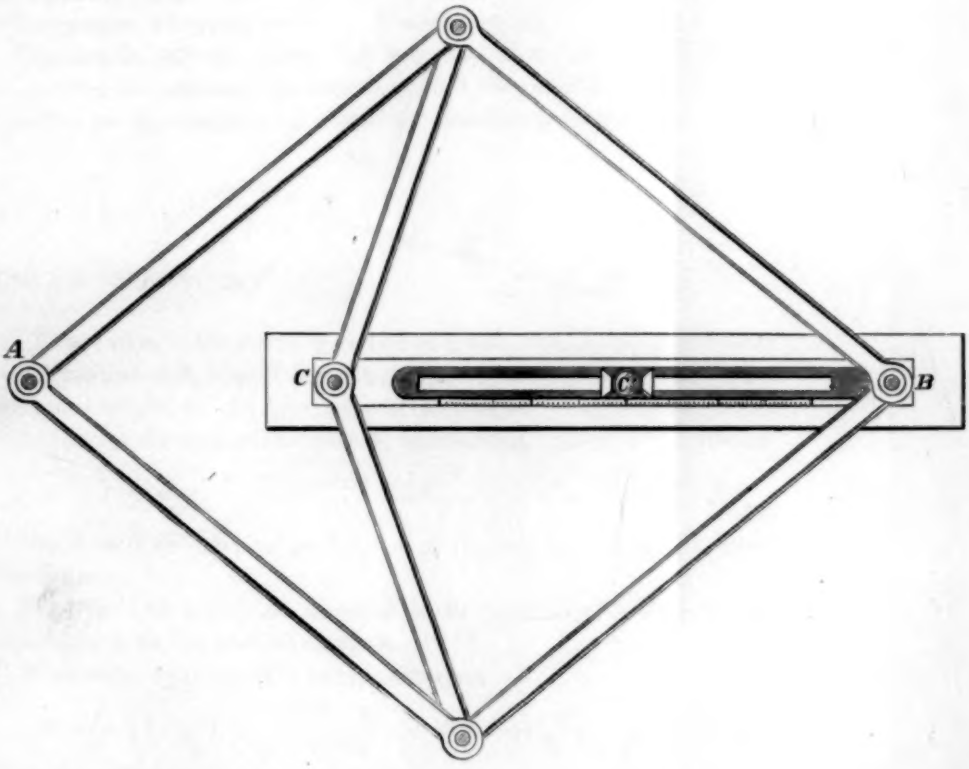
Radius	Convex arcs $+x =$	Concave arcs $-x =$
10 in.	1·500	3·000
20 “	0·857	1·200
30 “	0·600	0·750
40 “	0·462	0·545
50 “	0·375	0·428
60 “	0·316	0·353
70 “	0·273	0·300
80 “	0·240	0·261
90 “	0·214	0·231
100 “	0·194	0·207
110 “	0·177	0·188
120 “	0·162	0·171

and can be used for computing the value of x for circles of any radius from $3\frac{1}{3}$ inches to infinity or a straight line, with an instrument of the described proportions.

In order to use the instrument, place the ruler CB on any normal to the circle, adjust the joint at the required distance x and cause the pencil in the vertex A to coincide with the starting point of the circle sliding the ruler upon the normal until the proper position is reached. The circle can then be described.

Referring to the special elliptic linkage, Section 3 of Peaucellier's paper Fig. 4, if $OA = AB$ we have Fig. 8, $r = OA = AB$ and

Fig. 7.



$$x = r - \sqrt{r^2 - \frac{y^2 r^2}{(l-d)^2}}$$

and reducing

$$y^2 = \frac{(l-d)^2}{l^2}\,(2rx - x^2) \qquad (12)$$

which is the equation of an ellipse referred to its vertex and of which the major and minor semi-axes are r and $\frac{l-d}{l}\,r$.

When x is $+$, *i. e.*, moved to the right, the arc is convex to the pole C, and E[illegible] should be used; when $x = 0$ we have an arc of infinite r[illegible] the arc is [illegible] computin[illegible]

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At C^n [illegible] the verte[illegible] being ad[illegible] the slots [illegible] hundredt[illegible] both way[illegible]

The be[illegible] tively un[illegible] following[illegible] inches h[illegible] reduce to[illegible]

Radius	C	
10 in.		
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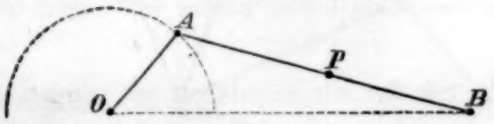
Referring to the special elliptic linkage, Section 3 of Peaucellier's paper Fig. 4, if $OA = AB$, we have Fig. 8, $r = OA = AB$ and $d = AP$ and

$$y^2 = \left(\frac{r-d}{r+d}\right)^2 \left(2(r+d)x - x^2\right)$$

the equation of an ellipse referred to its vertex of which the transverse and conjugate semi-axes are $(r+d)$ *and* $(r-d)$.

The case is different when AB is greater than OA and of interest, as covering the ordinary instance of a point on a connecting rod which describes an egg-shaped oval closely approximating to an ellipse.

Fig. 8.



The equation of the curve described by a point P at a distance d from A on the line AB, Fig. 8, when referred to rectangular co-ordinates with the origin in the perimeter at a distance $(r+d)$ from O, and with OB for the axis of abscissas is, representing AB by l; OA by r.

$$x = r + d - \frac{\sqrt{r^2(l-d)^2 - y^2 l^2} + \sqrt{d^2(l-d)^2 - d^2 y^2}}{l-d}. \qquad (10)$$

For $d = 0$ we have $y^2 = 2rx - x^2$ the equation of a circle with the radius r.

For $d = l$ we have $x = \infty$ which is the equation of a straight line coinciding with the axis of abscissas.

If we cause equation (10) to take the form

$$x = r\left(1 - \sqrt{1 - \frac{y^2 l^2}{(l-d)^2 r^2}}\right) + d\left(1 - \sqrt{1 - \frac{y^2}{(l-d)^2}}\right) \qquad (11)$$

and neglect the last term as inconsiderable when d is relatively small or l very great, we have

$$x = r - \sqrt{r^2 - \frac{y^2 l^2}{(l-d)^2}}$$

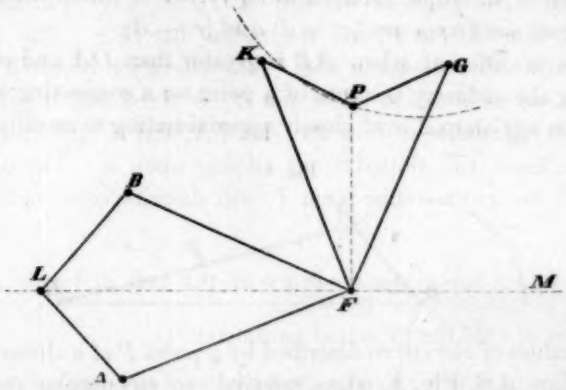
and reducing

$$y^2 = \frac{(l-d)^2}{l^2}(2rx - x^2) \qquad (12)$$

which is the equation of an ellipse referred to its vertex and of which the major and minor semi-axes are r and $\frac{l-d}{l}\,r$.

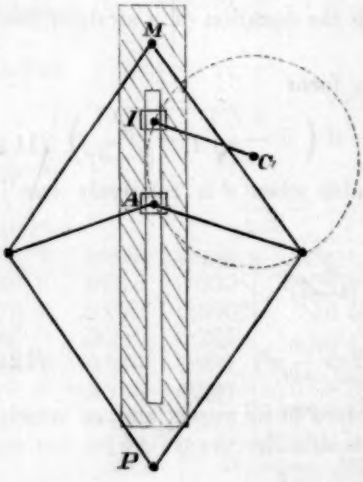
The special linkage shown in Fig. 9 was devised by Mr. Freeland, University of Pennsylvania, and will describe a hyperbola, it is a positive cell having the longer arms split and turned through a fixed angle, being fastened together at F, the arm AFK forming one piece,

Fig. 9.



and the arm BFG another. The point L being fixed, the point F is forced to move along the straight line LM, the point P will describe a hyperbola. The equation $\rho\rho^1 = m^2$ being that of a hyperbola referred to its asymptotes. In this case $m^2 = \frac{A^2 + B^2}{4}$, and A and B are the major and minor semi-axes of the hyberbola.

Fig. 10.



The limaçon of Pascal is a curve traced by a point on a line which projects a constant distance beyond the circumference and passes through a fixed point on the circumference of a circle.

In the combination of linkages shown in Fig. 5, the function of the cell ACC^1B is by means of the bar C^1CI to cause the prolongation of IM to pass through the point A in all its positions, as IM is rigidly fastened to ICC^1 and at right angles to it. In this linkage, the only

points fastened to the surface, upon which these two linkages move, are A and C.

This assemblage, although theoretically fulfilling the required conditions, is too complicated for ordinary purposes.

A good mechanical substitute is shown in Fig. 10, which is lettered as in Fig. 5. The place of the cell $A\,C\,C^1B$, Fig. 5, is supplied by the slotted ruler $M\,I\,A\,P$, and the radius bar $C_1\,I$. The same cell may be used as that shown in Fig. 7, the alteration required being in the ruler used as a basis. The pin C_1 is fixed and the radius bar can be made adjustable at I in the slot $I\,A$, and to any length. The point A is fixed, the slotted ruler sliding upon it. The point M is fastened to the ruler. The point P will describe conic sections as in Fig. 5.

$I\,M = \frac{m^2}{p}$, m being the modulus of the cell and p = the semi-latus rectum or half the principal parameter.

$C_1 I = \frac{m^2\,\varepsilon}{2p}$ in which ε = the eccentricity of the conic section.

We have now a ready mechanical means of describing any required straight line, circle, ellipse, parabola or hyperbola as the case may require.

Letting A = the transverse and B = the conjugate semi-axes, we have for an ellipse

$$I\,M = \frac{m^2\,A}{B^2} \text{ and } C_1\,I = \frac{m^2\sqrt{(A^2 - B^2)}}{2\,B^2}$$

For a hyperbola

$$I\,M = \frac{m^2\,A}{B^2} \text{ and } C_1\,I = \frac{m^2\sqrt{(A^2 + B^2)}}{2\,B^2}$$

For a parabola

$$I\,M = \frac{m^2}{p} \text{ and } C_1\,I = \frac{m^2}{2p}$$

Referring to the linkage for the cissoid, Fig. 6, we have

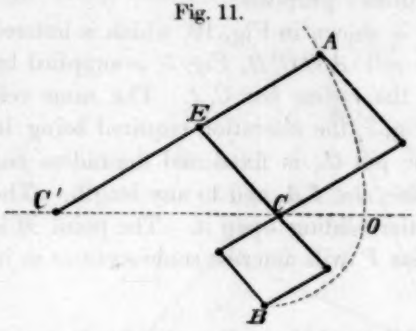
$$AB = CB - CA = \frac{m^2}{CA} - CA\,;\ \text{or,}$$

$$\rho = \frac{m^2}{\rho^1} - \rho^1 = \frac{m}{\cos.\ \alpha} - m\cos.\ \alpha = m\,\frac{\sin.^2\ \alpha}{\cos.\ \alpha} = m\sin.\ \alpha\ \tan.\ \alpha$$

which is the polar equation of the cissoid under the condition placed

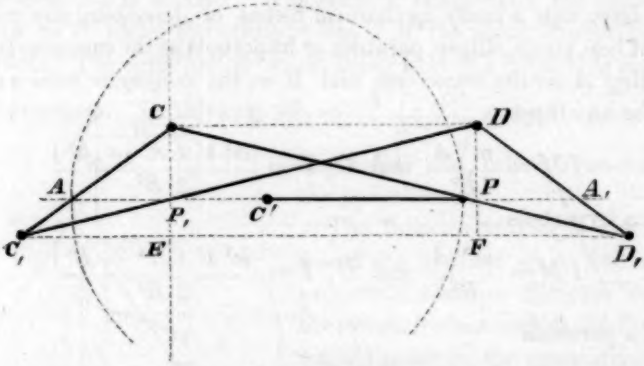
$C^1 A$, being the polar axis and m the diameter of the circle passing through A of a radius $= C^1 A = \frac{m}{2}$.

Fig. 11.



In Fig. 11 (this figure is distorted, each parallelogram should be a rhomb) is shown an ingenious adaptation of a linkage to the tracing of ellipses due to Mr. Freeland, student in this University. The point C^1 is fixed, the point C is forced to follow the straight line C^1CO, $C^1E = EA = EC$. The point A traces a circle of the radius C^1A, and the point B traces an ellipse OB. The point opposite to E in the large rhomb and the two unlettered points in the other, also describe ellipses.

Fig. 12.



We will close this brief essay by an explanation of Hart's Perfect Parallel Motion, which is described by Mr. Kempe in "How to Draw a Straight Line."

This linkage is remarkable, because only four rods are required where six are used in Peaucellier's cell. It will be perceived that this linkage CD_1DC_1C is a parallelogram in a reversed position, *i. e.* the rods CD_1 and C_1D instead of being parallel are crossed (Fig. 12).

Let a straight line AP_1PA_1 be drawn parallel to C_1D_1, cutting all the links in AP_1PA_1.

Let $AP = \rho$
" $AP_1 = \rho^1$
" $AC_1 = a_1$
" $AC = a_2$
" $CD = b$
" $C_1D_1 = b_1$
" $CC_1 = a_3$
" $C_1E = D_1F = d$
" $CE = DF = h$
$C_1D = b_3$

The similarity of the triangles CC_1D_1 and CAP and also C_1CD and C_1AP_1 which is true for all positions gives the two proportions

$$\frac{\rho}{b_1} = \frac{a_2}{a_3} \text{ and } \frac{\rho^1}{b} = \frac{a_1}{a_3}$$

$$\text{Therefore, } \rho\rho^1 = \frac{a^1a^2}{a_3^2} bb_1$$

But $bb^1 = b(b + 2d) = b^2 + 2bd$.

From the right angled triangles C_1FD and C_1EC we have $(b + d)^2 + h^2 = b_3^2$ and also $d^2 + h^2 = a_3^2$, subtracting the latter from the first we have

$$b_3^2 - a_3^2 = b^2 - 2bd = bb_1$$

$$\text{Therefore, } \rho\rho^1 = \frac{a_1 a_2}{a_3^2}(b_3^2 - a_3^2) = m^2.$$

All the terms of the second member of this equation being constants, we have a linkage with the same properties as the Peaucellier Compound Compass. The point A being fixed and either of the points P or P_1 being forced to move in a circle with the circumference, passing through A the other will describe a straight line. These points are interchangeable.

There are, of course, many other forms of linkages besides the ones described, and it is to be hoped that some mentioned in this paper can be greatly simplified.

The degree of exactitude which is required in the mechanical workshops of the United States is daily becoming greater, and at present tries our machinery to the utmost.

With the possibility of a mathematically straight line before us, with a means of describing an arc of a circle of any radius, in a convenient shape, and with the conic sections almost as easily describable as a circle; there is no reason why our mechanics should not produce machinery of an exactitude, and in forms hitherto deemed unattainable.

University of Pennsylvania, February 18th, 1879.

Wealth of France and England.—The national wealth of England is estimated at $39,200,000,000, that of France at $40,300,000,000.—*Fortsch. der Zeit.*

THE DRIVING POWER OF LEATHER BELTS.

By Robert Briggs, C. E.

In the Journal of the Franklin Institute for May will be found a translation of a paper on leather belts, which paper appeared in a communication to the Industrial Society of Mulhouse, in May, 1835. The following is the basis of the paper:

"The science of applied mechanics gives the formula relating to this subject as follows: Calling

P, the resistance to be overcome,
e, the base of Naperian logarithms,
f, the coefficient of friction of leather upon cast iron,
R, the radius of the pulley,
S, the length of the arc of contact.

"The formula is written thus:

$$\text{Friction} = P\left((e)^{\frac{fS}{R}} - 1\right)$$

* * * * * *

It is late to correct an erroneous deduction of forty-four years since, but as the paper is resuscitated with the evident purpose of showing or comparing the applicability of its results to present use, it is yet necessary to show that the whole article was founded on a mistake.

Adopting the formula in its present shape of

$$\text{Friction} = P\left((e)^{\frac{fS}{R}} - 1\right)$$

It will be found there should be placed for the word "Friction" some letter or character which should express the difference of tension between the tight and the slack side of the belt, that is the effective pull of the belt, and the value for P is that of the tension on the slack side of the belt.

The correct formulæ are:

Calling T_1 = tension on tight side of belt,
T_2 = " " slack " " "
P = effective pull on the belt = $T_1 - T_2$.

Then the "science of applied mechanics"* gives:

$$\frac{T_1}{T_2} = e^{\frac{fS}{R}}$$

$$P = T_1 \left(\frac{e^{\frac{fS}{R}} - 1}{e^{\frac{fS}{R}}} \right)$$

$$P = T_2 \left(e^{\frac{fS}{R}} - 1 \right)$$

The last of these formulæ is evidently that used by Mr. Heilmann.

The capability of the belt is manifestly its strength to resist the tension T_1 on the tight side of the belt, and consequently the figures of comparison of ratio of the effective pull to the tension on the slack side of the belt (which are those given in the paper) possess no practical value whatever.

While calling attention to the mistaken use of formula in this computation, it may be proper to show what would have proceeded from correct use with the data accepted by M. Heilmann; taking Moran's coefficient of friction and M. Laborde's table of force exerted by pulleys with 180° contact. When the ratio of effective force $= P$ to the tension on the tight side of a belt $= T_1$ for different angles of contact; for 0·122 frictional adhesion of belt to pulley becomes:

Angles	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°	360°
$\frac{P}{T_1}$ =	0·0619	0·0994	0·1744	0·2255	0·2734	0·3184	0·3605	0·4001	0·4371	0·4721	0·5047	0·5354

These figures give the multipliers of widths of belts as given in M. Laborde's tables for various angles of contact.

= 5·344	= 3·203	= 1·826	= 1·431	= 1·165	= 0	= 0·883	= 0·796	= 0·728	= 0·674	= 0·631	= 0·595

The above figures, however, possess only the merit of accurate computation; not having the least of use, as the coefficient of friction on which they are based is three and a half times too small for conformity with any practice.

It will be noticed that the paper assumes a value for f. "The ratio of friction to pressure for leather upon plane surfaces of cast iron has been taken from the experiments of M. Morin." A simple retrograd-

* "Rankine's Applied Mechanics," p. 618; the same will be found in any work on applied mechanics.

ing computation finds from the tables this assumed value to have been 0·122. Direct experiments, which can be repeated by any mechanic at any moment, have shown this ratio to be as large as 0·58 under favorable conditions, and that over 0·40 can be accepted as the *hold* of the belt in general practice.

In the JOURNAL (volume CVI), November, 1878, p. 309, the comment upon M. Laborde's paper computes the strain on the belts accepted as a basis by M. Laborde at 19·15 pounds per inch of width. This computation makes no distinction between the strain on the tight side of the belt and the *effective* strain on the same side accepted by M. Laborde as the measure of imparted force. If the friction of a belt on its pulley be taken at 0·42 and the angle of contact 180°, then the tension on the tight side of a belt exerting an effective pull of 19·15 pounds is 26·26 pounds and the tension on the slack side will be 7·11 pounds.

It may be well to recapitulate a table which was given some years since in the JOURNAL OF THE FRANKLIN INSTITUTE.*

Maximum strain on belting 66⅔ pounds per inch of width; coefficient of friction single leather belts on iron pulleys, 0·42.

Arc of contact,	90°	100°	110°	120°	135°	150°	180°	210°	240°	270°
Strain transmitted (pounds),	32·36	34·80	37·07	39·18	42·06	44·64	49·01	52·53	55.34	57·58
Tension, loose side,	34·31	31·87	29·60	27·49	24·61	22·03	17·66	14·14	11·33	9·09
Total tension on belt,	100·98	98·54	96·27	94·16	91·28	88·70	84·33	80·81	78·00	75·76
Strain between axes of pulleys derived from the belt when at work,	71·40	75·94	78·85	81·54	84·32	85·68	84·33	78·07	67·55	53·56
Tension on each side when at rest,	50·49	49·27	48·14	47·08	45·64	44·35	42·17	40·41	39·00	37·88

The last line shows how tight a belt must be made in order to give out its maximum strain of 66⅔ pounds per inch of width when at work.

Telegraphic Announcement of Freshets.—The minister of public works is experimenting upon the Lot, in the Department of l'Arveyron, with an electric apparatus for producing an automatic record of the variations in the level of rivers, so as to signal the occurrence of freshets as soon as they arise, in order to give the inhabitants of the river banks as much time as possible to ward off the danger. The apparatus employed is similar to one that was invented by one of the government engineers who is in the Algerian service. Professor Codazza, Sig. Cabella and Professor Ferrini have also devised indicators for the same purpose.—*L'Electricité; Il Politecnico.*

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* January, 1868.

SOME EXPERIMENTS ON ALLOYS OF SILVER WITH EMBRITTLING METALS.

Made at the United States Mint, Philadelphia,
BY
ALEXANDER E. OUTERBRIDGE, JR.

It is a fact very well known to metallurgists that the presence of certain base metals in refined gold and silver, even in such small percentages as to render their detection difficult, if not impracticable, by ordinary chemical tests, will nevertheless exercise such an injurious effect in regard to ductility, hardness, etc., as to render the metal totally unfit for coin or the industrial arts, thereby necessitating the removal of these impurities by oxidizing fluxes, or other equivalent means.

It is also well established that during the process of removing these impurities (technically called "toughening"), an inevitable, though variable, loss occurs.

This loss may be directly traced to three causes:

First. To the formation of volatile compounds of gold or silver with the baser metals.

Second. To the violent action on the surface of the metal during the decomposition of the oxidizing agent, thereby causing minute particles of the molten metal to be sprayed from the surface.

Third. To the upward current of air and flame sweeping over the surface of the molten metal in the pot drawing into the flue the vaporized metal and the fine spray.

These vapors are carried by the strong draught of the wind furnace out of the chimney, where they partially fall, in a sort of fine rain, upon the roof of the Mint and neighboring buildings, and a larger portion is carried into free space and lost.

Attempts have been made to recover the metal thus dissipated by means of shelves and other devices arranged in the flue, with but partial success, and they have the practical disadvantage of tending to impair the draught in the wind furnace.

It was to overcome these difficulties that an apparatus was devised by the writer to prevent the metallic vapors and gases arising from the

melting-pot from escaping into the flue at all by drawing them off into a suitable condensing chamber.

The Chief Assayer of the Mint, after examining the drawings, laid the whole matter before the late Director of the Mint in Washington, who in turn instructed the writer to have an experimental apparatus constructed, and "after it is finished to have it thoroughly tested by careful trials under the direction of the Melter and Refiner."

In accordance with these instructions the apparatus was made and erected at one of the furnaces in the melting department, and the trial tests were commenced on February 5th, 1878, and continued as opportunity offered until they were suspended, owing to the unprecedented increase in the regular work consequent upon the passage of the Bland Silver bill.

The arrangement of the experiments having been entrusted to the writer, he prepared a schedule of the proposed work, which was approved by the officers directly interested. It was designed by the writer that these trial melts should also subserve a broader purpose of furnishing reliable data as to the relatively injurious effects upon refined silver of small but known percentages of such base metals as were supposed to impair its good qualities. It is this secondary portion of the work which is now submitted, albeit in an incomplete form, to the readers of the JOURNAL OF THE FRANKLIN INSTITUTE.

The schedule as far as completed includes the preparation and subsequent examination, analysis and refining, of alloys of silver with arsenic, antimony, bismuth and lead.

About one thousand (1000) ounces of silver was adopted as the normal weight of refined metal to each experimental melt.*

With respect to the success of the apparatus, the writer desires merely to refer by permission to the brief extracts from letters of the officers, who observed its operation, which accompanied his report made to the late Superintendent of the Mint. These will be found in the foot note.†

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* Although the assay department long since adopted the French system of weights, viz., the gramme and its decimals, the troy ounce is still regarded as the unit or standard Mint weight, and is accordingly employed in these experiments.

† Professor Booth, the Melter and Refiner, in whose department the tests were made, after endorsing the accompanying report as expressing the results of the trials in their integrity, says, "In relation to the TRIAL OF APPARATUS, I remark that the principle underlying Mr. Outerbridge's process is sound, viz., to recover volatilized precious metals by drawing off the possible vapors above gold and silver in a crucible and

He also desires to say that the credit for the success which attended the tentative tests of the apparatus is largely due to the excellent suggestions in the mechanical details which were made by Mr. Samuel James, the Master Mechanic of the Mint, to whom was entrusted the construction of the machine, thereby materially improving the original design.

First Experiment—Silver alloyed with Arsenic.

Although the metal arsenic has a great affinity for silver, it will not readily combine with it in an open crucible, owing to its extreme volatility. The following expedient was therefore resorted to, with success:

A bar of silver which assayed 999 thousandths fine and weighed 100·46 ozs. (troy) was first melted with 3 ozs. of metallic arsenic in a black lead pot, with a lid luted on with fire-clay, and bound tightly with a metal strap.

The fire was brought up gradually for two hours, then a good white heat for half an hour; it was then allowed to slowly die out; the crucible remaining in its place was agitated in order to bring fresh surfaces of the molten silver in contact with the confined vapors of arsenic. A lump of charcoal was put in the crucible to prevent oxidation of the arsenic. When the pot was cold the "king" of metal was broken out, cleaned and weighed. It turned the scale at 102·98 ozs., showing that 2·52 ozs. of arsenic had combined with the silver.

The exterior surface of the "king," as it is technically called, presented a light grey color. On breaking it open this light shade was observed to extend to a depth of about $\frac{1}{20}$th of an inch; the interior showed a darker grey color, indicating that the surface contained a smaller proportion of arsenic. In order to ascertain this a piece was assayed from the surface and another from the interior, with the following result:

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wholly condensing them. I remark further that his mode of effecting the result is, I believe, new, simple, effective and inexpensive," etc.

Mr. Wm. E. DuBois, the Chief Assayer, after alluding at some length to the evils which the apparatus was designed to overcome, says: "These two points being kept in view by all concerned, it was interesting to observe the changes and modifications by which the system (as all systems are) was step by step improved and simplified, until it seems nearly complete. Certainly it is now in such a satisfactory shape as would warrant its introduction into the mints and assay offices and refineries generally; for it is well known that the evil which it abates is not confined to this institution."

Surface, ... 975 fine.
Interior, ... 971 fine.

It is possible that the portion of the metal touching the sides of the pot remained hot somewhat longer than the centre, owing to the fact that the pot remained in the fire until the whole had cooled. The volatile arsenic may thus have been driven (or distilled) *in* to the central portion of the solidifying mass.

The broken surface of the metal presented a clearly crystalline structure, and, although by no means so ductile as fine silver, it was far more so than could have been anticipated. The metal hammered and rolled without splitting. The solution in nitric acid was perfectly clear like fine silver, and no trace of arsenic could be detected by the eye or smell. Two samples of the alloy were preserved for future comparisons; one was rolled into a ribbon, to show the malleability; the other broken, to show the fracture.

In the next operation, 952 ozs. silver, 999 fine, were melted in a No. 40 black lead crucible. When the fine silver was perfectly fluid, the king of silver-arsenic alloy weighing 102·29 ozs., was added to the mass; the metal was then stirred and a sample for reference extracted

The metal was finally toughened in the ordinary way, using nitre and sand. At the end of one hour and a half the flux was skimmed from the surface and the metal poured into large shoe moulds.

The sample taken from the mass after the "king" was thoroughly incorporated, assayed 995¼, which agreed closely with the theoretical fineness, viz., 996. This sample was reserved for future experiments.

The mass metal, after having been toughened as above stated, was cast into bars, and assayed 998. The metal was then perfectly ductile, and no trace of arsenic could be detected by the eye.

The sweep resulting from the grinding of the crucible weighed 28½ lbs. avoirdupois, and contained 97·712 grs. of pure silver per pound avoirdupois. The sweep from the grinding of the ashes in the furnace weighed 58 lbs., and contained ·720 of a grain per lb. The entire weight of silver in both sweeps was thus found to be 1·12 oz. troy.

Second Experiment—with Antimony.

The toughened silver resulting from the previous experiment was manipulated in the following way:

One bar, 998 fine, weighing 119·60 ozs., was melted in a closed

crucible with 3 ozs. of metallic antimony, with the addition of charcoal to prevent oxidation. The pot was allowed to cool slowly (as in the previous experiment with arsenic), and the king of alloyed metal resulting was found to weigh 122·39 ozs., showing that 2·79 ozs. of antimony had combined with the silver. The king assayed 975 fine, and contained 2½ per cent. of antimony.

The metal was remarkably tough and ductile, rolling almost as well as fine silver; fracture crystalline and coarse.

Next a melt of silver bars, 998 fine, weighing 786·08 ozs. (resulting from the silver-arsenic experiment), was melted in a No. 40 black lead pot, under charcoal. As soon as it was fluid the king of antimonic-silver alloy was added. The whole was thoroughly stirred and a sample cast out for future experiments. This sample assayed 994 fine.

The metal was now exposed to a hot fire for a period of one hour and a half, a current of air being allowed to pass over the surface. Nitre was added occasionally in small quantities for the purpose of burning off the charcoal. During the entire time, the antimonic-oxyd was seen rising to the surface of the metal, and burning off with quite copious fumes, passing up the condensing tube. The water in the glass condensing chamber became very turbid, and the filter soon clogged up with a heavy sediment. The toughened metal was then cast into bars, and assayed 998 fine, and presented all the characteristics of fine silver.

The material on the filter was dried and collected. It weighed 1·15 ozs. An examination under the microscope showed that it was profusely sprinkled with extremely minute globules of metallic silver. These particles are nearly perfectly spherical, conclusively proving that they have been volatilized and condensed. The majority of the globules were very much smaller than the interstices of the filtering cloth, thus leading to the inference that a portion of the silver may have passed through the wash water, and thus escaped into the well. This fact was conclusively proved in the next experiment by collecting some of the water percolating through the filter, allowing it to settle, and recovering a button of pure silver from the sediment.

An analysis of the material showed that it contained one-seventh ($\frac{1}{7}$) silver, the remainder being antimonic-oxyd, colored by charcoal dust. The filter was burnt, and added to the precipitate; the metal was reduced to a button and cupelled. It weighed $\frac{13}{100}$ ounce.

Third Experiment—With Bismuth.

One bar of toughened silver (resulting from previous experiment) assaying 998, weighing 137·77 ozs. was melted in a closed (luted) crucible with 3 ounces of bismuth in the same manner as before. The king of alloyed metal weighed 140·73 ozs., showing that 2·96 ozs. of bismuth had combined with the silver. The king resembled exteriorly the antimonic-silver alloy, but on cutting into the metal, it was found (unlike the antimonic-silver) to be exceedingly brittle or "short" like pie-crust. The fracture presented a coarse grain with a lustreless or earthy surface. The color of the metal when hammered was very dark or leady, and the strips had a somewhat greasy feeling.

The sample assayed 975 fine, showing about 2½ per cent. of bismuth. A melt of 888·62 ozs. toughened silver, 998 fine, was then made in a No. 40 pot; as soon as it was melted the king was added. It was thoroughly incorporated with the mass by stirring; a sample was taken out and assayed 996 fine. The sample still showed plainly the "shortening" effect of bismuth; the fracture was crystalline and fine, the color was but slightly impaired and the assay slip rolled tolerably well.

The mass was now exposed to a high temperature for about three-quarters of an hour. Nitre was then added copiously, finally a small quantity of sand to thicken the flux just sufficiently to skim. The bars were cast into moulds, cleaned and weighed. On assaying the first and last bars it was found that but little or no improvement in fineness had occurred. The first bar assayed 996, the last 996½; they were consequently reported 996¼.

The difficulty was, according to Professor Booth, that the nitre being thin, failed to hold the oxyd of bismuth formed by its action. As soon as the oxygen (formed by the decomposition of the nitre) had been driven off, the reducing action of the black-lead pot caused the bismuth to go back to the metallic state, when it again formed an alloy with the metal. (This metal was afterwards refined to 999½ by the use of bone ash.)

As the examination of the precipitate collected on the filter in the previous experiment had revealed the fact that the volatilized silver globules were so minute as to lead to the inference that a portion had passed through the interstices of the filtering cloth, an effort was made to recover any particles thus escaping. The fact that the metal did so escape was conclusively proved in this experiment and a portion of the

fugitive particles recovered. In this case, the water percolating through the filter was caught in a large iron tank, the overflow from this tank discharged into a second filter composed of two thicknesses of fine twilled linen. The water in the tank was allowed to remain at rest for several hours and then drawn off. On testing the sediment in the tank, it was found to be rich in silver; it was then dried, treated with carbonate of soda in a sand-pot. A button of silver was obtained which was purified by cupellation and then weighed ·07 of an ounce.

The sediment collected on the second filter was treated as above with a similar result. Finally a portion of the water escaping through the second filter was collected and silver was traced here also.

Although many of these particles or globules are so minute that a microscope with a good magnifying power is required to see them, they may be readily and beautifully exhibited by agitating a beaker-glass full of the water in the sunlight, when thousands of brilliantly scintillating points of light are seen reflected from the extremely minute faces of the silver pellicles. A similar effect is described by Faraday in "Philosophical Transactions," 1857. By treating very dilute solutions of gold with phosphorus he obtained the metal diffused through the liquid in extremely fine particles. These particles he says "are easily rendered evident by gathering the rays of the sun (or a lamp) into a cone by a lens, and sending the part of the cone near the focus into the fluid; the cone becomes visible, and though the illuminated particles cannot be distinguished, because of their minuteness, yet the light they reflect is golden in character and seen to be abundant in proportion to the quantity of gold present." He further says that portions of gold, in such a fine state of division that "they have not as yet been seen by any power of the microscope, may have the presence of the diffused solid particles rendered evident by the sun in this way."

Supplemental Experiment with the Silver Bismuth Alloy.

As already stated, the alloyed metal resulting from the experiment with bismuth was found to retain four and a half thousanths of bismuth which the nitre had not removed. In accordance with the suggestion of Professor Booth, the metal was again melted and covered with a coating of bone ash, holes were made in this covering with an iron poker and grains of nitre were dropped through to the exposed surface of the molten metal; as fast as the bismuth was oxidized it

was absorbed and held by the bone ash (the principle being the same as in cupellation); at the end of about one hour, the bone ash was taken off, a fresh supply of nitre and sand added, the second flux skimmed off and the metal cast into bars. The condensing apparatus was not used, as it was supposed that the bone ash covering would protect the metal from volatilization. It was found, however, that a loss of 1·42 ozs. occurred. During the toughening, samples were taken out at intervals of twenty minutes and assayed; the first showed 997 the metal still remaining brittle. The second sample assayed 997¾ and was also brittle. The third assayed 999 and showed some brittleness, but the fracture presented a closer grain than in the two former samples. It was still quite unfit for coin ingot metal.

The bars when cast had all the appearance of fine silver, being perfectly ductile; they assayed 999½ fine. This result seems to indicate that small percentages of bismuth affect silver more injuriously, both in regard to its ductility and in respect to the difficulty of its elimination, than equal proportions of arsenic or antimony.

Fifth Experiment—Silver and Lead.

A bar of silver, 999½ fine, weighing 82·83 ozs., was melted under charcoal with 3 ozs. of pure lead in a closed crucible. The king of alloyed metal weighed 85·61 ozs., showing that 2·78 ozs. of lead had combined with the silver.

The exterior of the king had a white or frosted appearance. On cutting an assay chip, the metal was found to be very brittle, having a dull leaden color. The fracture was not very clearly crystalline, but seemed more like the effect of a mechanical tearing away of the metal. A similar effect was noticed in rolling and hammering the assay slip, for while it broke to pieces under the hammer, it seemed to be crumbly (like dry bread) rather than brittle. Under ordinary inspection, however, it would have been simply classed as brittle. The sample from the king assayed 960, or contained 4 per cent. of lead. A melt of bars, 999½ fine, weighing 931·53, was then made in a No. 40 black-lead pot. The king was added, mixed, and a sample cast; this sample assayed 996¼. It was fairly ductile, had a good lustre and color, but when compared with a strip of fine silver it was appreciably (though not greatly) darker in tint.

A coating of bone ash was put on and the nitreing performed as in the previous case. Samples were taken out and assayed from time to

time until the metal was found to be sufficiently refined. In about one hour the bone ash was removed and the bars cast. Owing to some accidental cause (probably the want of a sufficient covering of charcoal), the metal "spurted" or "vegetated" on the surface, rendering it necessary to remelt and recast the bars, and when this was done they presented to the eye all the characteristics of perfectly pure metal. When the small chip was cut off for assay, there was no evidence of a tendency to crystallization, and the sample was laminated into a ribbon $\frac{1}{100}$th of an inch in thickness, without splitting. The assay showed that the metal was now refined to 999½ thousandths.

To briefly recapitulate, the results obtained in this work—which the writer desires shall be regarded rather as preliminary, and therefore capable of possible modification on more extended investigation—are these:

It was ascertained that the arsenical silver alloy, contrary to the general expectation, was the least volatilizing in silver in comparison with more refractory metals, and that the alloy might contain one per cent. of arsenic (silver 990, arsenic 10) without materially injuring the ductility; but if carried to two and a half per cent., the mixture was quite brittle.

The antimonic-silver alloy caused a very much greater loss of silver, and yet its brittling effect was much less than had been anticipated. Bismuth was the most brittling, and in this experiment proved by far the most difficult to remove by fluxes that operated effectively upon the two former.

Lead caused a greater loss than any of the former with the exception of antimony. The brittleness of those was crystalline, of this rather crumbly or amorphous, yet three parts in a thousand did not spoil the ductility.

While it has been a source of regret to the writer that these trials have been suspended, for the reason given, prior to the completion of the pre-arranged schedule, he is led to hope that they may form the entering wedge into future investigations, which are much needed to afford a complete elucidation of the difficulties that beset the manipulator in the precious metals, whether in the preparation of coin metal, ornamental ware or gold leaf, in the want of ductility of the alloys, and he is also encouraged to think that they may serve to throw a passing glimmer of light upon this rather obscure subject, in support

of which hope he refers the reader to an extract on this subject from the letter of the assayer, already alluded to.*

Tables.

The following tabular statement shows the gross weight of metal operated upon in each experiment and the amount of fine silver contained therein, together with the gross weight and amount of fine silver recovered from the toughening process:

FIRST EXPERIMENT.	OUNCES.	
	Gross Weight.	Fine Silver.
Refined silver, 999 fine,	1052·46	
Metallic arsenic,	2·52	
Total weight of metal operated on,	1054·98	1051·40
Total weight of metal recovered in the form of bars, samples and "sweep,"	1053·32	1051·15
Apparent loss of silver,		·25
SECOND EXPERIMENT.		
Refined silver, 998 fine,	905·68	
Metallic antimony,	2·79	
Total weight of metal operated on,	908·47	903·86
Total weight of metal recovered,	903·16	900·21
Apparent loss of silver,		3·65

* "I took a particular interest in this investigation for two reasons: First, I was sure that we knew too little practically about the effect of a small presence of such metals as arsenic, lead, etc. That is, we depended too much upon supposition, as to the extent or the degree in which they were injurious to the precious metals for coining purposes. It was worth while to make some severe and decisive tests upon that point. * * * As you have already seen by Mr. Outerbridge's report in detail, the alloying and volatilizing experiments were made with four metals in conjunction with silver, namely: arsenic, antimony, bismuth and lead. These are the chief enemies that trouble the camp of the silver miner and refiner. Nor are they less dreaded at the mint, since a small proportion of either will make our gold or silver refractory, brittle, crystalline or crumbly. * * * We must have ductile metal to work with. Hence these experiments have for us, as I have said, a twofold interest, as hitherto there have been no trials that we know of, at home or abroad, on any considerable scale, or in proper bulk. * * * On the whole we have learned a good deal, and I hope these experiments, without respect to the saving from waste, may be made accessible to parties interested in our own land and in foreign parts"

THIRD EXPERIMENT.

Refined silver, 998 fine, . . .	1026·39	
Metallic bismuth, . . .	2·96	
Total weight of metal operated on, .	1029·35	1024·33
Total weight of metal recovered, .	1027·18	1023·31
Apparent loss of silver, . . .		1·02

FOURTH EXPERIMENT—(*Supplemental*).

Silver-bismuth alloy, 996¼ fine, . .	1020·56	1016·73
Total weight of metal recovered, .	1015·79	1015·31
Apparent loss of silver, . . .		1·42

FIFTH EXPERIMENT.

Refined silver, 999½ fine, . .	1014·36	
Metallic lead, ...	2·78	
Total weight of metal operated on, .	1017·14	1013·85
Total weight of metal recovered, .	1011·78	1010·78
Apparent loss of silver, . . .		3·07

REMARKS ON THE GENERAL THEORY OF THE CENTRIFUGAL GOVERNOR FOR STEAM ENGINES.

By L. D'AURIA,

Professor of Applied Mechanics; former Engineer of the Military Topographic Institute in Italy, Marine Architect, etc.

In any centrifugal governor, the masses moved by the centrifugal force resist the rotation by the inertia with a force equal to the masses multiplied by the acceleration. This force acting tangentially, it occasions a certain friction which resists the radial movement of said masses by the centrifugal force, which friction must be taken in consideration in the equation of dynamical equilibrium of the system.

If we indicate by ΣW, the sum of the weights moved by the centrifugal force in any centrifugal governor; by ρ, the variable distance of their common centre of gravity from the axis of rotation (the weights ΣW are supposed to have the same point of suspension); by

θ, the angle made by the axis of rotation with the straight line joining the centre of gravity of ΣW with the suspension; by N_1 and N respectively the numbers of revolutions per minute required by the governor to act when in its lower position calculated with and without the influence of the tangential force of inertia; by t, the time in which the governor passes from the speed of N to N_1 revolutions per min., which passage we suppose takes place with uniformly accelerated motion; the equation of dynamical equilibrium will be, according to the supposition,

$$\frac{\Sigma W}{900\,g.} N_1^2 \pi^2 \rho \cos.\theta = \Sigma W \sin.\theta + f \frac{\Sigma W}{180\,g.\,t} (N_1 - N)$$

in which the last term represents the tangential force of inertia multiplied by a coefficient f of friction, which reduced the friction to a resistant force applied at the centre of gravity of the weights ΣW.

Now from this equation we obtain

$$N_1 = \tfrac{5}{2} \frac{f}{t\pi \cos.\theta} + \sqrt{\frac{25}{4} \frac{f^2}{t^2 \pi^2 \cos.^2\theta} + \frac{900\,g.\,tang.\,\theta}{\pi^2 \rho} - \frac{5Nf}{t\pi \cos.\theta}}$$

and observing that

$$\frac{900\,g.\,tang.\,\theta}{\pi^2 \rho} = N^2$$

will be

$$N_1 = N;$$

which shows how harmless the tangential force of inertia is in centrifugal governors, and how useless are the devices proposed by some inventors for the elimination of the friction arising from it.

Molecular Vibrations in Magnetic Metals.—De la Rive showed, in 1846, that when a rapidly interrupted electric current traverses a stretched iron wire it produces sounds corresponding to the number of interruptions. M. Ader reports some late experiments which lead him to the following conclusions: 1. With all magnetic metals the passage of an undulatory current produces internal molecular vibrations which yield audible sounds. 2. In order to increase the intensity of the vibrations, some mechanical action should be opposed to the wires or bars, such as the inertia of two heavy masses at their extremities. The experiments are most successful with a battery which furnishes electricity in quantity and with a short circuit.—*Comptes Rendus.*

THE following table of elements was constructed from a similar one intended for the instruction of the classes in the University of Pennsylvania in 1873, and will be found a useful table of reference for historical and statistical data.

Such a table, constructed with due care, can never represent the exact condition of chemistry at the time, for the reason that chemical investigation is always in advance of its general literature.

1879.

TABLE OF ELEMENTS.

Prepared for the course of Lectures at the Franklin Institute, on Introduction to Modern Chemistry, by PERSIFOR FRAZER, JR., A. M.

Name.	Symbol.	Atom Wt.	*Ap. Val.	†Molecule.	‡State.	Discoverer.	Date.	Anode.
Aluminum	Al	27.4	IV, $(Al_2)^{VI}$		Solid	Woehler	1823	O
Antimony	Sb	122	III, v		"	Valentine	14—	S
Arsenic	As	75	III, v,	Tetratomic	"	Schroeder	1694	N
Barium	Ba	137	II,	Monatomic, (?)	"	Davy	1808	F
Bismuth	Bi	210	III		"	Agricola	1529	Cl
Boron	B	11	III		"	Davy	1807	Br
Bromine	Br	80	I, iii, v, vii		Liquid	Balard	1826	I
Cadmium	Cd	112	II,	Monatomic	Solid	Stromeyer	1817	Se
Caesium	Cs	133	I		"	Bunsen	1860	P
Calcium	Ca	40	II		"	Davy	1808	As
Carbon	C	12	ii, IV		"	Ancients		Cr
Cerium	Ce	92	II		"	Berz. and Hisinger	1803	V
Chlorine	Cl	35 5	I, iii, v, vii		Gas	Scheele	1774	Mo
Chromium	Cr	52.4	II, iv, $(Cr_2^{\prime\prime})^{VI}$		Solid	Vauquelin	1797	W
Cobalt	Co	59	II, iv, $(Co_2)^{VI}$		"	Brandt	1733	B
Copper	Cu	63.4	II $(Cu_2)^{II}$		"	Ancients		C
Didymium	D	96	II		"	Mosander	1841	Sb
Erbium	E	113 7	II		"	Mosander	1843	Te
Fluorine	F	19	I		Gas	Knox (?)	1886	Ta
Gallium	Ga	70(?)			Solid	Boisbaudran	1875	Cb
Glucinum Be. or	G	9.4	II		"	Woehler	1828	Ti
Gold	Au	197	III		"	Ancients		Si
Hydrogen	H	1	I		Gas	Cavendish	1766	H
Indium	In	113.7	III		Solid	Reich and Richter	1863	Au
Iodine	I	127	I, iii, v, vii		"	Courtois	1812	Os
Iridium	Ir	198	ii, IV		"	Tennant	1804	Ir
Iron	Fe	56	II, iv, $(Fe_2)^{VI}$		"	Ancients		Pt
Lanthanum	La	92.5	II		"	Mosander	1889	Ro
Lead	Pb	207	ii, IV		"	Ancients		Ru
Lithium	Li	7	I		"	Davy	1818	Pd.
Magnesium	Mg	24	II		"	"	1808	Hg
Manganese	Mn	55	II, iv, $(Mn_2)^{VI}$		"	Gahn	1774	Ag
Mercury	Hg	200	II, $(Hg_2)^{II}$	Monat.	Liquid	Ancients		Cu
Molybdenum	Mo	95.8	ii, iv. VI		Solid	Hjelm	1782	U
Nickel	Ni	59	II, iv, $(Ni_2)^{VI}$		"	Cronstedt	1751	Bi
Niobium	Nb	94	V		"	Hatchett	1801	Sn
Nitrogen	N	14	III, v		Gas	Rutherford	1772	In
Osmium	Os	199.2	ii, IV		Solid	Tennant	1803	Pb
Oxygen	O	16	II	Di. and Triat.	Gas	Priestley	1774	Cd
Palladium	Pd	106.6	ii, IV		Solid	Wollaston	1803	Tl
Phosphorus	P	31	III, v,	Tetratomic	"	Brandt	1669	Co
Platinum	Pt	197.4	ii, IV		"	Wood	1741	Ni
Potassium	K	39.1	I,		"	Davy	1807	Fe
Rhodium	Ro	104.4	ii, IV		"	Wollaston	1803	Zn
Rubidium	Rb	85.4	I		"	Bunsen	1860	Mn
Ruthenium	Ru	104.4	ii, IV		"	Claus	1845	La
Selenium	Se	79.4	II, iv, vi,	Di. & Hexat.	"	Berzelius	1817	D
Silicon	Si	28	IV		"	"	1823	Ce
Silver	Ag	108	I,		"	Ancients		Th
Sodium	Na	23	I,		"	Davy	1807	Zr
Strontium	Sr	87 5	II,		"	"	1808	Al
Sulphur	S	32	II, iv, vi,	Di. & Hexat.	"	Ancients		E
Tantalum	Ta	182	V		"	Ekeberg	1802	Y
Tellurium	Te	128	II, iv, vi		"	Klaproth	1798	G
Thallium	Tl	204	I, iii		"	Crookes	1861	Mg
Thorium	Th	231	IV		"	Berzelius	1829	Ca
Tin	Sn	118	ii. IV		"	Ancients		Sr
Titanium	Ti	50	IV		"	Klaproth	1794	Ba
Tungsten	W	184	iv, VI		"	De Luyart		Li
Uranium	U	240	ii, iv, $(U_2)^{VI}$		"	Peligot	1841	Na
Vanadium	V	51 3	iii, $(V_2)^{IV}$,	$V,(V_2)^{VIII}$	"	Sefstroem	1830	K
Yttrium	Y	6.7	II		"	Woehler		Rb
Zinc	Zn	65	II	Monatomic (?)	"	Paracelsus	15—	Cs
Zirconium	Zr	89.6	IV		"	Berzelius	1824	

*Apparent Valences. †Elements not otherwise marked are presumed to have a diatomic molecule. ‡At ordinary temperatures.

Cathode.

phosphorus in most objectionable quantities. In the twenty-four coals tested from this bed, the amount of phosphorus varies from a mere trace to ·1248 per cent., equal to ·2003 per cent. in the coke. Such a coke could not, of course, be used in the manufacture of Bessemer pig iron, and it is believed that in many cases unsatisfactory results have been obtained simply by the use of an impure fuel.

cular vibrations which yield audible sounds. 2. In order to increase the intensity of the vibrations, some mechanical action should be opposed to the wires or bars, such as the inertia of two heavy masses at their extremities. The experiments are most successful with a battery which furnishes electricity in quantity and with a short circuit.—*Comptes Rendus.*

PHOSPHORUS IN COAL.

By Andrew S. McCreath, Harrisburg, Pa.

Read at the Pittsburgh Meeting of the American Institute of Mining Engineers, May 13th, 1879.

The manufacture of pig iron for conversion into steel by the Bessemer and open-hearth processes, is now one of the most important industries of the United States. It is necessary that iron intended for this purpose should be very pure, and especially must it be comparatively free from phosphorus. Great care must therefore be exercised in the selection of proper ores, flux, and fuel. Only such ores as are practically free from phosphorus can be used, and pure fuel is as much a necessity as pure ores; though hitherto iron men have paid comparatively little attention to this point.

During the course of my work as chemist for the Second Geological Survey of Pennsylvania, I had occasion to examine some of the bituminous coals of the State for phosphorus, and the results obtained are so interesting that I venture to present them to the notice of the members of the Institute.

The coals are arranged in geological order according to the different beds, and the table shows the percentage of phosphorus in the coal and also in the coke.

The greatest number of specimens have been selected from the Pittsburgh bed, because it is the principal coal-bed of South-western Pennsylvania, and most of the mineral fuel which is mined along the Youghiogheny and Monongahela rivers, to be used in the coke ovens of the Connellsville region and in the blast furnaces and mills of Pittsburgh and its vicinity, and to be shipped to Western and Southern markets, comes from this bed.

It will be noticed that many of the specimens examined contain phosphorus in most objectionable quantities. In the twenty-four coals tested from this bed, the amount of phosphorus varies from a mere trace to ·1248 per cent., equal to ·2003 per cent. in the coke. Such a coke could not, of course, be used in the manufacture of Bessemer pig iron, and it is believed that in many cases unsatisfactory results have been obtained simply by the use of an impure fuel.

Table showing the Percentage of Phosphorus in Certain Coals.

	Name of Coal.	County.	Coal bed.	Phos. per ct. in coal.	Phos. per ct. in coke.
1	Henderson's, Buffalo Township	Washington.	Washington.	·1667	·2818
2	Lucas's, Dunkard Township	Greene.	Sewickley.	·0053	·0084
3	Miller's, Dunkard Township	"	Pittsburgh.	·0025	·0041
4	Magee's, Independence	Washington.	"	·0254	·0438
5	Ashurst's, Chartiers	"	"	·0491	·0846
6	Red's, Fallowfield	"	"	·0943	·1551
7	New Eagle Works, Carroll Township	"	"	·0013	·0020
8	White's, East Pike Run Township	"	"	·1248	·2003
9	Slocum's, East Pike Run Township	"	"	·0011	·0018
10	Penn Gas Coal Co.'s Youghiogheny Shaft	Westmoreland.	"	·0058	·0095
11	Penn Gas Coal Co.'s Penn Shaft	"	"	trace.	trace.
12	Penn Gas Coal Co.'s Sewickley Shaft	"	"	trace.	trace.
13	Westmoreland Coal Co.'s Southside Mine	"	"	·0092	·0150
14	Westmoreland Coal Co.'s Larimer Mine	"	"	trace.	trace.
15	Westmoreland Coal Co.'s Foster Mine	"	"	·0402	·0652
16	Millwood Coal Co.'s, Derry Township	"	"	·0801	·1177
17	Saltzburg Coal Co.'s, Loyalhanna Township	"	"	·0307	·0452
18	Saxman & Co.'s, Derry Township	"	"	·0167	·0247
19	Greensburg Coal Co.'s, Hempfield Township	"	"	·0070	·0107
20	Frick & Co.'s, Connellsville Township	Fayette.	"	·0111	·0161
21	Townsend's, Perry Township	"	"	·0022	·0034
22	McCormack Heirs, Franklin Township	"	"	trace.	trace.
23	Swan Heirs, North Union Township	"	"	trace.	trace.
24	Kendal's, German Township	"	"	·0020	·0031
25	Saylor Hill, Summit Township	Somerset.	"	·0058	·0074
26	Wilhelm Mine, Elk Lick Township	"	"	·0122	·0156
27	Coleman Brothers, Valley Township	"	Berlin.	·0105	·0135
28	Cotter's, Raccoon Township	Beaver.	Bed E.	·0058	·0094
29	Dysart & Co.'s, Washington Township	Cambria.	"	·0530	·0688
30	Dennison, Porter & Co.'s, Allegheny Township	Blair.	"	·0075	·0103
31	Diehl's, Green Township	Beaver.	Bed D.	trace.	trace.
32	R. J. Hughes & Co.'s, Decatur Township	Clearfield.	"	·0089	·0107
33	Rockhill Iron and Coal Co.'s, Carbon Township	Huntingdon.	"	trace.	trace.
34	Joseph Ramsey, Jr.'s, White Township	Cambria.	Bed C.	·0078	·0105
35	Dennison, Porter & Co.'s, Allegheny Township	Blair.	Bed B.	·0053	·0072
36	Cambria Iron Co.'s, Allegheny Township	"	"	trace.	trace.
37	Cambria Iron Co.'s, Conemaugh Township	Cambria.	"	trace.	trace.
38	Dysart & Co.'s, Washington Township	"	"	trace.	trace.
39	Brotherline's, Clearfield Township	"	"	trace.	trace.
40	Savage Colliery, Todd Township	Huntingdon.	.....	·0080	·0098

Substitution of Steel for Iron.—The first iron vessel was built in 1820, for the trade between London and France. Thirty years afterwards the tonnage of the iron steamers was only one-fourth as great as that of the wooden steamers. In 1860 nearly four-fifths of the English steamer tonnage was iron; in 1868 nearly ten-elevenths of the tonnage was iron. Prior to 1870 only 27,000 tons of steel had been used in ship building; since that time the price of steel has steadily approximated to that of iron, and the production of steel has increased twentyfold. The leading railroads are gradually replacing their iron rails by steel, which cost but little more and last three times as long. A similar substitution is gradually taking place in the ship yards.—*Fortsch. der Zeit.*

NOTE ON THE DETERMINATION OF SILICON IN PIG IRON AND STEEL.

By Dr. Thomas M. Drown, Lafayette College, Easton, Pa.

(Read at the Baltimore meeting of the American Institute of Mining Engineers, February, 1879.)

In experimenting in connection with Mr. P. W. Shimer (now chemist of the Thomas Iron Company, Hokendauqua, Pa.), on methods for the determination of silicon in pig iron, in order to find one which should be accurate and yet give results in a few hours, I have adopted the following procedure, which, as far as my experience goes, leaves nothing to be desired.

About one gramme of pig iron or steel is treated in a platinum or porcelain dish with 25 cubic centimetres of nitric acid (sp. gr. 1, 2). When action has ceased, 25 to 30 cubic centimetres of dilute sulphuric acid (one of acid and three of water) are added, and heat applied until the nitric acid is nearly or quite driven off. The heat of a water-bath is sufficient, though the process may be hastened by heating higher on a sand-bath. Water is then cautiously added (as soon as the free sulphuric acid is sufficiently cool) and the contents of the dish heated until the crystals of ferric sulphate are completely dissolved. The solution is then filtered *as hot* as possible, the residue washed first with hot water, then with 25 to 30 cubic centimetres of hydrochloric acid (sp. gr. 1, 12), and finally with hot water. After drying and igniting, the silica will be found to be snow-white and granular.

The following are some results obtained by this method compared (in some instances) with the older method of treatment with nitric acid, evaporation to dryness, heating to 150°C. for several hours, dissolving out the iron in hydrochloric acid, and filtering off from the insoluble residue, which is dried and ignited, and the resulting impure silica fused with alkaline carbonates.

The letters denote different samples of pig iron.

	Per Cent. of Silicon.							
	A	B	C	D	E	F	G	Bessemer steel.
Old method,	2·64	2·46		1·45	1·65			·672
New method, 1	2·70	2·47	1·13	1·63	1·53†	1·66	2·50	·676
" " 2	2·68	2·47	1·18	1·62	1·51†	1·68	2·50	·672
" " 3	2·81*	2·47		1·65	1·51†	1·72	2·50	·672
" " 4					1·63‡	1·70	2·47	
" " 5					1·65‡		2·46	
" " 6					1·65‡			

Some incidental results obtained in developing this process have enough interest to be worthy of record. Treatment of pig iron with concentrated sulphuric acid, heating till fumes arise, diluting with water, and filtering after all action has ceased, gives a silica which is seldom pure, and yet the results are considerably too low.

Treatment with dilute sulphuric acid and evaporation till the acid fumes in the air, then filtering after dilution, gives occasionally results which are accurate; but this method is uncertain, depending on the fineness of the borings and character and composition of the pig iron. The silica obtained is seldom white. The following are some results obtained in this way:

	Per Cent. of Silicon.			
	A	B	C	D
Old method . . .	1·02	1·64	2·64	3·85
New method, 1 . .	1·05	1·73	3·00	3·88
" " 2 . .	1·05	1·69	2·98	3·91
" " 3 . .	1·05	1·70	2·97	
" " 4 . .			3·01	

* Not washed with hydrochloric acid.

† In these analyses hydrochloric acid was used after the addition of nitric acid, and was not completely driven off.

‡ Hydrochloric acid was used for solution instead of nitric acid.

Treatment in platinum dishes gave very slightly lower results than porcelain dishes.

If after treatment with dilute sulphuric acid the solution is filtered off from the residue without concentration of the acid, it is found that about one-half of the silicon is in the solution and the other half in the residue; when nitric acid is used and the solution filtered off as soon as all action has ceased, it is found that about two-thirds of the silicon is in the solution and one-third in the residue; and with hydrochloric acid, about one-third goes into solution and two-thirds remains in the residue. It is not probable that there is any precise ratio existing between the amount of silicon dissolved and the amount in the residue in the case of any one of the acids, the ratio being doubtless variable and depending on the concentration of the acid, the time of action, and the temperature; yet the marked difference in the action of the three acids in this respect is interesting.

The washing with hydrochloric acid of the residue obtained by the action of nitric and sulphuric acids on pig iron is in most cases necessary. Thus there was obtained from a pig iron when water only was used for washing, 2·67 per cent. of silicon against 2·52 when washed with hydrochloric acid; and in another sample, 2.10 per cent. against 1·70 per cent.

Although the results obtained with hydrochloric acid for the original solution of the iron show, as far as the experiments go, as good results as those obtained with nitric acid, yet I prefer the nitric acid treatment on account of the silica obtained, being compact and granular, while the use of hydrochloric acid, and also of sulphuric acid alone, yields a silica which is light and flaky.

Lactic Fermentation.—Richet has studied the effects of oxygen, of boiling, and of digestives, upon lactic fermentation. He finds that the fermentation in an elongated tube is only from 65 to 70 per cent. as great as in an ordinary flask. Below 44° (111·2° Fahr.) the activity of fermentation increases with the temperature. From 44° to 52° (125·6° Fahr.) there is no change; above 52° the activity diminishes in proportion as the temperature increases. He attributes the resistance of boiled milk to fermentation to the coagulation of an albuminoid substance which contributes to the devolopment of the ferment.—*Comptes Rendus.* C.

REPORT OF THE COMMITTEE ON SCIENCE AND THE ARTS ON THE HITCHCOCK LAMP.

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, April 2, 1879.

The Sub-committee of the Committee on Science and the Arts, constituted by the Franklin Institute of the State of Pennsylvania, to whom was referred for examination the Hitchcock Lamp, report that the apparatus is a mechanical (or blast) lamp of improved construction, which, in the form submitted for examination, is especially adapted for consuming fat or greasy oils, animal or vegetable, and without the aid of a chimney, the oil being supplied to the wick by the same mechanism that supplies the blast. Leaving out of consideration for the present the general features of mechanical excellence of construction which characterize the lamp, and which, by giving it superior strength and accuracy of working, add to its utility and durability, your committee find that the special novelty in its construction lies in the functions which the mechanism is called upon to perform—that is to say, to furnish a forced blast or draft to the flame and at the same time to deliver the oil to the wick, both of which operations are performed simultaneously and continuously so long as the mechanism is working. This feature will appear more distinctly by instituting a comparison between the Hitchcock lamp and other mechanical lamps with which your committee is familiar.

The Carcel lamp is designed to burn fat oils. The air supply to the flame is obtained by the use of a chimney of about 11 inches in height, while the oil is supplied to the flame by a mechanical movement.

The Jones & Hitchcock lamp—the immediate predecessor of the lamp before the committee—is designed to burn kerosene without a chimney, the necessary air supply being obtained by mechanical means.

In the Carcel lamp, with a chimney, the movement supplies the oil to the flame. In the Jones & Hitchcock lamp, without a chimney, the movement furnishes the air supply to the flame. In the Hitchcock lamp before the committee the movement combines both these functions, supplying the blast and feeding the oil simultaneously.

As compared with either the Carcel or the Jones & Hitchcock lamp, the movement is more compact and considerably more effective, pos-

sessing the capacity of furnishing a continuous light for 12 hours, while that of the Carcel and Jones & Hitchcock are limited respectively to 6 and 7 hours.

Referring to the mechanical details and workmanship displayed in the Hitchcock lamp, your committee find it in these particulars worthy of unqualified praise, and, of the two samples before the committee, one has been kept in almost continuous experimental service for over a year and the other about half that time, and with very satisfactory results.

The lamp can readily be taken apart for cleaning and repairs, the principle elements—*i. e.* the movement, the pump and the wick tube—being readily removable from the shell or body, and as easily returned.

The elliptical form of the wick tube, in the opinion of your committee, has several advantages over both the flat and the cylindrica wick, as the flat form gives no interior current of air, and would be quite inapplicable to this form of lamp by making the combustion imperfect; and the circular wick, though avoiding this objection, does not utilize the interior air current as effectively as the elliptical or compressed form, which gives practically the same results as regards luminosity as two flat flames.

The committee have been aided in getting at the illuminating value of the lamp by the courtesy of Dr. Cresson, whose comparative photometric measurements and results are given herewith on his authority:

Results of Experimental Trials with the "Hitchcock Blast Lamp" from the Hitchcock Lamp Company. (*No Chimney.*)

PHILADELPHIA, July 18, 1876,
417 Walnut Street.

Car Lamp with LARD OIL:

Specific gravity of oil,	0·911
Or 1 U. S. gallon weighed	7·59 pounds.

Continuous trial of 12 hours' duration.
Hourly observations upon consumption of oil.
Half-hourly observations upon candle power.

Average consumption of oil per hour,	922·4 grains.
Average light produced,	16·9 candles.
Average consumption of oil per candle light,	54·5 grains.

Or 1 gallon of oil will give 16·9 candle light for 57 hours.

When solid lard was used:

Hourly consumption of lard,	882· grains.
Light produced,	14·85 candles.

Average consumption of lard per candle light, 59·4 grains.
One pound of lard gives light of . . 117·8 candles.

Trials with Thackara & Buck's best Lard-oil Burner, with glass chimney 8 inches high, gave:

Average consumption of oil per hour, . . 805· grains.
Average light, ... 13·4 candles.
Grains of oil per candle light, . . 60·5

The best and most economical results were obtained from the Hitchcock lamp when it was giving a light equal to that from 17 candles. When it was burned at the rate of 15 candles the consumption of oil per candle light rose to 57 grains, and when at 21 candle lights to 70 grains per candle light.

The ordinary solar lamp could not be made to yield over 16 candles, and burned best at 13·5 candles, and at all times was very sensitive to cross-drafts and motion of the lamp.

The Hitchcock lamp gave decidedly the most satisfactory results, with the great advantage of the absence of a glass chimney, behaving well when placed in a strong draft of air, or when carried from place to place.

Car candles used for comparison burned at 209 grains per hour, and gave a light of 2·2 standard spermaceti candles, consuming 120 grains of sperm per hour. The above results are given in standard candle lights.

To this favorable opinion of Dr. Cresson, which your committee fully endorse, it should be added that the body of the lamp never becomes too hot for comfortable handling, even after burning for 12 hours, the maximum temperature being attained in about 5 or 6 hours.

The lamp is portable, and, your committee is advised, is made in a variety of styles and shapes to suit special services. The style before the committee is that employed in railway cars. The flame is very tenacious and the light very steady, requiring but little attention when the wick is properly trimmed and adjusted.

Your committee are of the opinion that the lamp combines the features of excellence, of mechanical construction and utility. Detailed drawings of lamp accompany this report—all of which is respectfully submitted.

WILLIAM H. WAHL, *Chairman.*
L. L. CHENEY,
ALBERT G. BUZBY.

Amended and adopted, May 7, 1879.
H. CARTWRIGHT,
Chairman pro tem.

ABSTRACT OF A REPORT OF EXPERIMENTS ON THE EFFICIENCY OF COKE GAS-GENERATORS WITH VARYING DRAFT.

Conducted under the auspices of the Verein von Gas- und Wasserfachmännern of Germany, by a committee consisting of E. Grahn, Simon Schiele, Dr. Schilling, and published in the Journal of the Society.

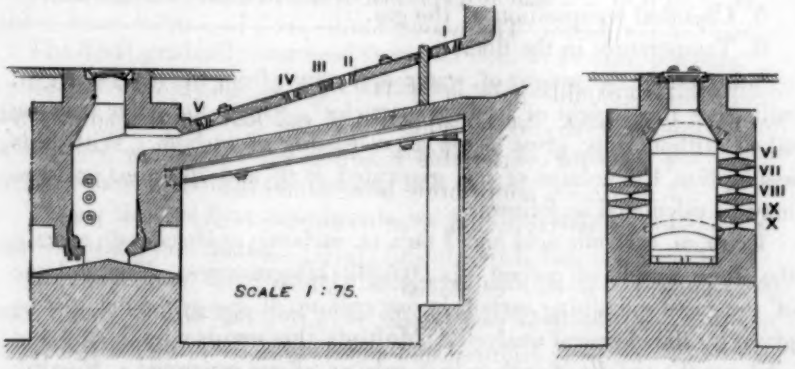
Translated by PHILIP PISTOR.

The experiments were conducted on the plan proposed by Dr. Bunte and adopted by the Society.

Carbonic oxide is most advantageously generated when it occurs continuously in unvarying quantities with the smallest possible percentage of carbonic acid and in such a manner that the operation is not disturbed by the removal of the slag or scoriæ deposited.

Experiments were conducted with a view to determine:

1. The quantity of gas generated in a given time.
2. The mean composition of the gas.
3. The formation and removal of the slag.



The experimental generator had at first no grate (one was introduced later during the experiments), but two slits or openings at the bottom, opposite each other, for the admission of air. It had 1 sq. metre cross section. From the upper edge of slit to lower edge of flue 1·5 m. The flue was of 0·25 sq. m. sectional area. Peep-holes were introduced in the sides every 0·25 m. of the height. The generator was charged from a hole in the top, which was closed with a flat luted

cover. The draft was regulated by a damper in the flue. As a chimney of 36 m. height was available for the experiments, and it was desirable to obtain the full natural draft, the gases were conducted through a combustion chamber, to avoid danger of explosion in the chimney, to the same.

The draft pressure was determined by two manometers, one an ordinary water manometer for rough approximate measurements, the other a very sensitive one for precise measurements. Besides, an automatic self-registering Crosley manometer was used. They were connected by tubes with the flue. Experiments showed that it made no difference which way the openings of these tubes were directed with reference to the direction of the draft.

An aspirator exhausted small quantities of the gas at different times during each experiment, for analyzing purposes, and specimens were also taken from the peep-holes.

The following observations were recorded during each experiment:

1. Mean draft in flue.
2. Duration of experiment.
3. Weight of material charged.
4. Weight of ashes, clinkers, scoriæ.
5. Chemical composition of the gas.
6. Temperature in the flue.

Subtracting the weight of water and refuse from the mass charged, will give the weight of gasified particles*, which for coke may be taken without any great error as consisting of carbon. With this assumption, the volume of gas generated at 0° and 760 mm. pressure may be calculated as follows:

1 cub. m. carbonic acid and 1 cub. m. carbonic oxide contain exactly the same weight of carbon, viz., 0·5363 kilogrammes. The volume of the gases containing carbon in one cub. m. of gas generated will be given by the chemical analysis. Multiply this number by 0·5363 and we have the weight of carbon in 1 cub. m. of gas generated. Finally, this weight into the total weight of carbon consumed will give the total volume of gas generated.

* The correction for weight of water was not taken into account, as it was found to vary as much for one and the same as for different kinds of coke.

Results of experiments with coke from Saar coal (Heinitz mines).

No. of Experiment.	Consumption of coke per 24 hours in kilog.	Refuse residue of coke in kilog.	Percentage of refuse, etc.	Actual consumption in kilog.	Gas generated contained a percentage of			Computed volume of gas per 24 h. reduced to 0° and 760 mm. barom. pressure.	Temperatures measured with Siemens' copper pyrometer or with the Siemens' electrical pyrometer.			Average draft pressure in mm. water.
					CO_2	CO	Total.		In flue. *a.*	In flue. *b.*	In generator.	
								cub. m.				
1	785	111	14·1	674	2·	28·3	30·3	4110	500	550	725 to 750	+0·74
2	800	113	14·1	687	1·5	29·2	30·7	4189	400 to 500	550 to 575	750 to 800	+0·43
3	1200	151	12·6	1049	1·8	28·6	30·4	6396				−0·65
4	1330	167	12·6	1163	2·5	27·3	29·8	7091	550		800	−1·64
5	1650	188	11·4	1462	3·	26·9	29·9	9137	700 to 750	800 to 850		−2·8
6	1800	226	12·6	1574	3·3	26·9	30·2	9837	1130°			−3·7
7	1980	268	13·5	1712	3·5	26·2	29·7	10700	714		748	−4·1
8	2530	329	13·	2201	5·6	22·9	28·5	14386	800 to 900			−6·7
9	3226	409	12·7	2817	7·	23·3	30·3	17335	832			−14·

The draft gradually increased from ·45 mm. to 14 mm. pressure.

Experiments 1, 2, 3, 4 were conducted with a low draft, the upper layer of coke only attaining a cherry-red heat. Analysis showed an absence of oxygen. No difficulty was found in removing the slag—it flowed down through the opening and chilled.

Taking the first four experiments, we get an average of 0·164 kilog. carbon to the cub. metre.

Experiments 5, 6, 7 give 0·16 kilog. per cub. metre. During these experiments the damper was wider open, the draft considerably stronger ane the generator itself quite warm.

Experiment 8 gives 0·153 kilog. carbon per cub. metre. During this experiment a pan of water was placed before the slit, considerably reducing the heat radiated, and more thoroughly chilling the slag.

Experiment 9 gives 0·1625 kilog. carbon per cub. metre; no water used, but full available draft. The generator was intensely hot, the coke itself at a white heat.

The temperatures *a* and *b* in flue are taken at about 2 metres from each other.

Results of a series of experiments with coke from Bohemian coal from the Lititz colliery, near Pilsen.

No. of Experiment.	Consumption of coke per 24 h. in kilog.	Refuse residue, etc. of coke in kilog.	Percentage of refuse, etc.	Actual consumption in kilog.	Gas generated contained a percentage of			Comp. vol. per 24 h. reduced to 0° and 760 mm. barom. pressure in cub. m.	1 cub. metre contains carbon in kilog.	Temperature measured by a pyrometer. In flue.		Average draft pressure in mm. water.
					CO_2	CO	Total.			*a.*	*b.*	
A	904	163	18·9	741	1·4	29·4	30·8	4486	·165	430 to 480	600 to 625	+0·86
J	1338	351	26·2	987	3·6	25·0	28·6	6435	·153			—4·6
Z	1400	353	25·3	1047	2·3	24·4	26·7	7322	·143		950°	—2·1
D	1462	362	24·8	1100	1·8	28·2	30·	6837	·161	750		—0·55
H	1516	391	25·7	1125	7·4	20·7	28·1	7465	·151	850	950	—5·2
N	1610	274	17·	1336						730		—3·1
F	1690	312	18·5	1378	7·2	20·3	27·5	9210	·150	770		—6·0
G	1815	400	22·	1415	8·3	16·7	25·	10554	·134			—7·4
B	1770	280	15·8	1490	3·6	23·2	26·8	10365	·144			—4·5
K	1920	384	20·	1536	5·6	23·4	29·	9876	·155			—8 2
M	2107	421	20·	1686	5·2	23·6	28 8	10916	·154	880		—7·2
P	2160	367	17·	1793								—6·2
O	2190	372	17·	1818								—6·7
C	2714	271	16·9	2443	6·3	21·1	27 4	21590	·113	800	950 to 975	—5·24
E	3707	487	13·14	3220	12·5					850		—11·8

The draft was gradually increased, being regulated by the damper, from Experiments A to E, that is, from 0·86 mm. to 11·8 mm. pressure. As can be readily seen, the consumption of coal grows with it.

Experiments G, H, J, K were conducted with the original generator.

Experiments A, B were conducted with a mixture of the two kinds of coke.

It was then found necessary to take out the fire-brick lining at the bottom of the generator opening, and for bricks tapering inward to substitute such tapering outward, on account of the formation of slag, which choked the opening.

Experiment F was conducted with the modified generator and mixed coke, half of each.

Experiments L, M with ·9 of the latter kind, ·1 of the former.

Experiments C, D, E with mixed coke and introduction of steam.

Experiments N, O, P with a grate introduced in the generator and steam; Bohemian coke.

The slightest leak in the generator or flue showed an immediate increase of carbonic acid. In the duct or flue, as the tables show, the temperature fell from 100 to 150° from *a* to *b*, a distance of about 2 metres. This indicates a very rapid cooling of the gases, and shows the advisability of the shortest practicable duct to the combustion chamber.

A very remarkable result is that when the steam or vapor of water was used, notwithstanding the chilling of the air supplied for carbonization, the temperature of the gases was hardly any lower than when steam was not used. It would seem that the heat, partly radiated from generator and flue and partly utilized in melting the slag, was sufficient to decompose the water and produce a gas richer in hydrogen.

The high temperature of the carbonized gases causes an increased deposit of tar in the standpipes and hydraulic mains of gas works, and consequently when first introduced must be closely watched.

Pyrometric measurements of the air which was heated by being led around the side of the oven before being introduced into the combustion chamber show a temperature of 475°C. in this duct. As regards the formation of slag, the mixture of the two kinds of coke gave by far the best results.

As yet these generators have only been introduced in one large gas works in this country (United States), viz., the People's Gas Works, of Baltimore, Md., by their Chief Engineer, Mr. Dietrich. A short description of them was given at the meeting of the Society of Gas Lighting, Dec. 12th, 1878, and will be found in the *American Journal of Gas Lighting* of Jan. 16th, 1879.

The above experiments show widely varying results, depending principally on the quality of coke used, and consequently should be repeated with our own coals.

As a very considerable saving in fuel is claimed for this method of firing, as it considerably reduces the expense and increases the uniformity of firing, it would seem to be to the interest of some of the larger establishments to conduct a similar series of experiments, which would give reliable data for coke from American coals.

THEORY OF THE TELEPHONE.

The telephone, which was so easily explained in the beginning, is enveloped in difficulties, and requires to be studied attentively. The iron plate vibrating under the influence of the voice in the transmitter, and subject to the action of the magnet in the receiver, was regarded as indispensable. We know now that it is possible to replace it in the receiver by non-magnetic substances, by a plate of copper, of glass, of wood, and even of card-board. It was believed then that the magnet exercises a particular action upon the bodies.

We have been mistaken, not in the fact, but in its cause, and if the glass, the wood, and other substances not magnetic transmit the sound, it is because the wood which surrounds and contains the magnet receives the molecular vibrations which are there produced, and communicates them to the substances which are applied to them.

To prove this fact, I availed myself of a microphone as a transmitter, and of a metronome, of which the strokes were regular and uniform and liable to little deviation, while you could study the conditions which gave more or less intensity in the receiving telephone.

It was possible to separate the mouth-piece of the telephone and the diaphragm of iron, and replace it by a glass plate. If you then applied the ear, after having well appreciated the intensity of the strokes which were heard, and raised it little by little to one side only, keeping the other side of the telephone supported, so that the distance could be measured, the intensity underneath diminished hardly any, and when it was placed at a right angle to the side of the instrument, the strokes had nearly the same force; but when you separated the wood a little, the sound stopped, and it was necessary to conclude that the case of the telephone even transmitted vibrations, for as soon as the edge of the glass came to be touched the strokes of the metronome were heard.

You hear equally well by applying the ear to the extremity of a thin glass plate of twenty-five centimetres, the other end of which rested on the side of the telephone. The same experiments have been made with plates of copper, of wood, and of card-board, the differences in the intensity of the sounds noticed being only due to the greater or less facility with which bodies of different natures receive and transmit vibrations. With a plate of iron, the strokes transmitted

are much stronger, and have a particular sound which diminishes rapidly in proportion as you raise the plate; and it is easy to understand that it is the influence of the magnet which is thus enfeebled, while the effect of the molecular vibrations of the case keeps up and causes it to be heard, as in the case of plates which were not magnetic.

It must be inferred, then, that in a telephone receiver the iron diaphragm is subjected to a double influence: that of the magnet and the case in which in which it is fixed, and as a practical consequence it is shown that in the construction of a telephone the choice of the case and the manner in which the magnet is fixed are not indifferent matters.

These facts confirm the opinion of Du Moncel, who attributes the effects of the telephone to molecular vibrations of the magnet, and the iron diaphragm only strengthens the vibrations and renders them more sensible to the ear in vibrating itself. The same causes act also in the transmitting telephone, but in an inverse sense; that is to say, the molecular vibrations excited in the case are transmitted to the magnet, and produce in the magnetism of the bar modifications which are transferred by induction currents to the coil. We may say, also, that the vibrations of the case are transmitted directly to the coil in the presence of a magnet producing the induction currents. This manner of regarding it will conform more to what is known of the origin of indirect currents.

Whatever conclusions may be drawn from the facts, the following can be used in the argument: By raising the mouth-piece, and the iron diaphragm of the telephone, and holding it firmly in the one hand, and with the other drawing a violin bow lightly upon the edge, you obtain a sharp sound that can be heard clearly in the receiving telephone. A small ruler placed crosswise before the instrument, and passing beyond it some centimeters, produces a sound when struck at the end with the bow, so that when it is shortened the sounds are elevated and gave those of an ascending gamut, which immediately came to the ear at the receiver. What is surprising in this experiment is that the grave notes, which shake the instrument and the hand, are not heard in the receiver, while the sharp notes are reproduced there easily, and the reason perhaps is because the vibrations from the sharp sounds approach to the character of molecular vibrations. It is perhaps needless to say that with an iron diaphragm these facts assume an entirely different character. It has already been demonstrated that the strokes made on the magnet, the coil or the case were heard in the

receiver. The molecular shock which sufficed for the telephone receiver is too feeble to cause the transmitter to speak. Besides it may be said that the iron diaghragm, vibrating by speech, exercises a double influence, and that to the magnetic effects in the bar may be added the vibrations which it directly transmits to the case.

The effects from the telephone are too usually attributed to the sensible vibrations of the iron plate moving backward and forward from the magnet, representing the well known and habitually accepted action; but the molecular vibrations which are performed, so to speak, atom by atom in the immovable plate, play a more important part, and without them articulated speech would be impossible.

The telephone and, above all, the microphone prove to us by surprising phenomena just how far the division and reciprocity of forces may go. But what is still more admirable than these new and marvelous instruments is the old and incomparable delicacy of the ear, which perceives and appreciates, without allowing to escape from it a single one of the thousands of movements which loose themselves in some manner in the infinitely little.—*Les Mondes.*

CARBURETTING AIR.

The cost required to produce the electric light is not easily obtained, but enough is known at present to condemn it as too expensive for commercial use; but the cost of carburetted air or gas is indisputably confirmed by practical experiment.

Practical Test.—Barometer 29·8, temperature 56°; the weight of gasoline, 655 grains to water, 1000 grains; therefore, one gallon of gasoline = 45,850 grains. The air was simply aspirated at the rate of 6 cubic feet per hour through an ordinary chemist's wash bottle, and each cubic foot took up 735 grains illuminating gas of 17·10 candles, taking 585 grains.

$$\text{1000 cubic feeet of air} = \frac{\text{Grains. } 735{,}000}{\text{1 gallon of gasoline} = 48{,}850} = 16{\cdot}0 \text{ gallons of gasoline per 1000 cubic feet of air.}$$

$$\text{1000 cub. ft., 17·10 gas,} = \frac{585{,}000}{\text{1 gallon of gasoline} = 45{,}850} = 12{\cdot}7 \text{ gallons of gasoline per 1000 cubic feet of gas.}$$

1000 cubic feet of air, after being carburetted, = 1320 cubic feet,

and 1000 cubic feet of 17·10 gas, after being carburretted, = 1270 cubic feet.

Specific-Gravity Test.—The time required to pass equal volumes of air, gas, carburetted gas and carburretted air under equal pressure through the same aperture (Shilling's test), was: air, 88 secs.; gas, 58 secs.; carburetted gas, 90 secs. corburetted air, 104 secs.

Gas, $\frac{58^2}{88^2} = \cdot 434$ to air 1.000.

Carburetted gas, $\frac{90^2}{88^2} = 1.045$ to air 1.000.

Carburetted air, $\frac{104^2}{88^2} = 1.396$ to air 1.000.

Photometric Test.—Test on Hartley's improved photometer, 15-hole argand burner (old standard), 7-in. by 2-in. chimney, consuming 2·04 cubic feet per hour of carburetted gas, = 14·59 standard candles; reduced to the standard of 5·00 cubic feet, = 37·78 standard candles.

Also, with No. 1 steatite batwing, consuming 2·40 cubic feet per hour, = 18·63 standard candles: reduced to the standard of 5·00 cubic feet, = 38·83 standard candles.

3·48 cubic feet per hour of carburetted air consumed through argand burner = 16·52 candles: reduced to the standard of five cubic feet, = 23·70 candles.

Durability Test.—The durability of 1·10 cubic foot 4-inch flame:

	Min.	Sec.
Gas,	5	45
Carburetted gas,	16	38
Carburetted air,	11	24

Various forms of machines were experimented on, viz.: cylinders containing lamp cotton, sponge, felt, and wood carbon. They are all useless and obstructive, nor do they yield so high or regular a light as air aspirated or exhausted through gasoline and charged into a gas-holder, from which it is supplied ready for use at the burner when required.—*Engineering.*

[Two great objections still exist to the use of these machines, viz., the impossibility of storing large quantities of gasoline without the risk from fire to property in the neighborhood, and secondly, that if the pressure becomes excessive, the flame from the burner will be blown out, and terrible explosions, resulting in loss of life, have followed in consequence. The increase in the illuminating property of coal gas, as

ordinarily furnished, when passed through these machines, is very great, and the flame, also, is not liable to be blown out with increased pressure, and a wide field seems to be open in this direction if all danger from fire in the carburetting of the gas could be done away with.]

UNDERGROUND TELEGRAPHING.

Two systems have been proposed, each of which has its advocates. In one, known as the Alberger plan, tubes of glass are prepared of a convenient length and about one-eighth of an inch internal diameter, in which a steel wire is introduced. The compound tube is then inserted in an iron one, which is placed in a furnace and brought to a welding heat, and then passed through a set of rolls, reducing the iron pipe sufficiently to make a solid mass of pipe, glass and coating. This coating of iron not only acts as a protector, but is a shield and an arrestor of the induced currents which are so troublesome in telegraphing on the ordinary lines. The wire being perfectly insulated and protected from all outside influence, is capable of working to a higher capacity, it is claimed, and with less resistance than any other known system. To connect the wires, a trench is dug of any depth desired and a battery attached to the first piece of pipe and tested with a galvanometer, and so with each one, the wire being connected by the ordinary telegraph tie. A sleeve somewhat longer than the pipe, of bell shape, is drawn over each joint when connections are made. This sleeve has an orifice in the centre, into which is poured, in a liquid state, an insulating fluid that fills the entrance of the sleeve, making a joint impervious to moisture and perfectly insulated.

The second system is the invention of David Brooks, the well-known electrician, who has long entertained the belief that a plan of underground telegraphy could be devised which would be far superior, in point of economy and convenience, to the overhead one, despite many experiments in this country and elsewhere to the contrary, the great object being to find something which once placed in a pipe containing wires would prove impenetrable to moisture, water having such effect upon underground lines that a very little would be sufficient to destroy all communication. After trying many substances, he commenced to experiment with oils, and his system consists in placing the wires, wrapped in cotton, twenty, thirty or more in an iron pipe of the

proper size, and, after it is laid, oil is introduced and allowed to run its entire length, the source of supply being an elevated vessel always kept full, so as to keep a constant pressure on the oil already there, such pipes having been first laid in Philadelphia. The strong point in the new system is its economy, and it is found in the fact that any number of wires may be enclosed, as has been remarked, in a small space, each one being a separate means of communication, while the work of laying them does not involve much expense. Once in place, they are free from disturbances of all kinds. It is probable, therefore, that no more pole lines will be erected in cities, and our telephone wires over the roofs of houses be done away with.

NEW APPLICATION OF PAPER.

A list of the various useful purposes to which paper or *papier maché* has been applied during the last few years is remarkable by reason of the great diversity which it presents. Besides ornamental articles of almost every form, sundry articles of clothing, bedding, stamps, boxes, barrels, picture-frames, various articles of furniture, stove-pipes, chimney-pots, bricks, partition walls of houses, carriage wheels and boats figure amongst the multitude of appliances to which the inventive ingenuity of manufacturers has succeeded in adapting this single substance, and almost every week some new production is recorded. The last application to which this useful material has been put is the result of a peculiarly ingenius idea. Professor Greene, of the Polytechnic Institute at Troy, has recently had an astronomical observatory erected, the revolving dome of which is to have an internal diameter of twenty-nine feet. A dome of this size, constructed in the usual manner, would have weighed from five to six tons, and would, consequently, have necessitated foundations of considerable depth for its support, but, in addition, would have required powerful and complicated machinery in order to move it. While considering these conditions, the idea struck the astronomer that the substance which had been already put to such multifarious uses could be made to serve his purpose in a satisfactory manner. He therefore applied to a manufacturer of *papier maché*, who, under his direction, constructed a dome which fulfilled in every respect the anticipations that had been formed. In place of the heavy metal framework, such

as is usually employed in such structures, a light but firm framing of wood has been erected, and on this the paper. By means of a special preparation, this substance has been rendered fully as hard as the wood and even more rigid than the latter substance. It has been reduced, by subjecting it to enormous pressure, to a thickness of one-sixth of an inch. Thus the total weight of the dome, instead of amounting to some five or six tons, does not exceed a ton and three-quarters; and being mounted on pivots six-eighths of an inch in diameter, working in iron grooves, the whole is capable of being revolved in any direction required without the assistance of any machine or apparatus of any kind. We are not informed what is the difference of cost between such a construction and one answering the same purpose made in the ordinary way, but it is probable that the difference would be considerable, independently of the saving in machinery and of the economy which must result from the employment of a far less solid foundation than would have been necessary in order to support a dome of metal. There is, therefore, every reason to believe that the adoption of this system presents wonderful advantages from numerous points of view. —*L'Ingenieur Universel.*

ELECTRIC LIGHT AT THE BRITISH MUSEUM.

The experimental lighting of the reading-room of the British Museum by means of the electric light has proved a great success. This immense building, which is surmounted by one of the largest domes in the world, was recently illuminated for several evenings by Jablochkoff candles. Fifteen out of nineteen reading-desks with which the room is furnished were lighted by eleven candles, each enclosed in an opalized glass globe and placed on a pedestal fifteen feet high fixed in the centre of the desk, a twelfth lamp being placed in the centre of the room. The effect was very striking, the light being sufficiently bright to enable the smallest print to be read, and writing, tracing, drawing, and even coloring, to be accomplished with ease and comfort at each of the desks. The source of electricity was a 20-light Gramme machine, driven by a Robey portable engine of 16 nominal horse-power. Four circuits of four lamps each were used, twelve being placed in the reading-room, one in the entrance-hall, one in the portico and two in the machine and engine-shed. On this occasion an

improved form of the electric candle was used for the first time, in which the kaolin seam or dividing plate is replaced by a composition which is a feeble conductor of electricity.

By this modification the use of carbon priming for lighting and relighting is dispensed with, and the necessity of relighting by hand avoided, and one or several candles may be lighted or extinguished at once by simply turning the handle of a suitable commutator. Moreover, if one of the candles should become extinguished from any accidental cause, it will immediately relight itself without affecting its neighbors in the same circuit. The trial of the electric light under these conditions has given such satisfactory results that it has been decided to extend the application of this system of lighting to other parts of the building, so that hereafter the public will be able to visit the British Museum in the evening—a privilege which has been denied them hitherto, the trustees having been unwilling to expose that magnificent establishment to the risk which is inseparable from gas-lighting.—*L'Ingenieur Universel.*

JAMIN ELECTRIC LIGHT.

The greatest possible simplicity is claimed for it. The two carbons are kept parallel by two insulated copper tubes, separated by an interval of two or three millimetres, in which they slide by friction and which serve at once to direct them and to guide the current. They are surrounded by a directing circuit composed of five or six spirals coiled on a thin rectangular frame, ·40 m. long and ·15 m. broad. This circuit, traversed by the same current as the carbons, and in the same direction, guides and fixes the electric arc at the extremity of the points.

The lighting is effected automatically. For this purpose the two extremities of the carbons are surrounded by a thin rubber band, which keeps them close together. Between them, a little above, a small fragment of iron wire is introduced, which keeps them in close communication by a single point. As soon as the circuit is closed the current traverses this wire, makes it red-hot and melts the rubber; the two carbons thus freed separate, and the arc is established. Carbons of any size may be employed up to 8 mm. diameter. At this limit the waste scarcely exceeds 1·08 m. per hour. The apparatus may be suspended either with the points upwards or directed towards the

ground. For several reasons the latter is preferable. With its points downwards, Jamin claims for the light the following advantages: 1. That of simplicity, since it requires no mechanism and no preliminary preparation; all is reduced to a support and to carbons. 2. That of mechanical economy, since it succeeds in almost doubling the number of lights. 3. Increase of illumination, since each of the new lights is nearly twice as powerful as the old. 4. Quality of light, which is more white. 5. A more advantageous arrangement of the poles, which throw their greatest amount of light downwards, where it is required, instead of losing it towards the sky, where it is useless. 6. Economy of the combustible material, since the waste is less in proportion to the size of the carbons.—*Nature.*

Colored Pencils.—L. von Faber makes pencils for writing upon glass, porcelain, metal, etc., as follows—Black: ten parts of lamp black, forty parts white wax, ten parts tallow. White: forty parts white lead, twenty parts wax, ten parts tallow. Blue: ten parts Berlin blue, twenty parts wax, ten parts tallow. Dark blue: fifteen parts Berlin blue, five parts gum arabic, ten parts tallow. Yellow: ten parts chrome yellow, twenty parts wax, ten parts tallow.—*Dingler's Journal.* C.

Astronomical Museum.—Admiral Mouchey proposes to form an astronomical museum in the Paris Observatory. It is to contain: 1. A collection of the portraits of the astronomers and learned men who have distinguished the observatory since its foundation. 2. A collection of medals relative to the history of astronomy and of the observatory. 3. A collection of designs, engravings and photographs representing celestial bodies and astronomical phenomena. Many of these documents, such as Cassini's beautiful collection of drawings of the moon, have been almost forgotten and are now inaccessible to many astronomers who would feel a great interest in consulting them. 4. A collection as complete and methodical as possible of old astronomical and physical instruments, and of everything which can be found in connection with the base of the metric system. 5. Reduced models of instruments which are now in use in foreign observatories, and of special arrangements in those observatories which appear to be useful. —*La Nature.* C.

Estimation of Manganese, especially in its Alloys with Iron.—By F. Kessler.—The author gives details of improvements on a process published by him in the *Zeitschr.*, II., 255; the original was available to determine manganese up to thirteen per cent., but as the percentage of manganese may now reach ninety, a modification became requisite.

The solution of iron and manganese as chlorides is slightly over-saturated with sodium carbonate solution (100 grammes of crytals to the litre), and hydrochloric acid (1·01 sp. gr.) is then added until the solution just clears. Both these liquids are best run in gradually from burettes. After diluting, sodium sulphate solution (100 grammes of crystals to the litre) is added to the cold solution in the proportion of 15 c. c. for each gramme of iron; and the whole, after being made up to a known volume, is filtered uninterruptedly through a dry filter. Mere traces of iron remain in solution and do not interfere with the titration of the manganese. From 50 to 150 c. c. of this filtrate, which must not contain more than 1 decigramme of manganese (as previously determined by the estimation of the iron), are then added to a mixture of 100 c. c. of saturated bromine water with 20 c. c. of sodium acetate solution (500 grammes of crystals to the litre), and 50 c. c. of zinc chloride solution (200 grammes of zinc to the litre). The solution containing manganese should be added in five nearly equal portions at intervals of a quarter of an hour. Then 20 c. c. more of the above sodium acetate solution are added, and the whole boiled until the smell and color of bromine have vanished. The precipitate is then rinsed out into a filter, washed with dilute sodium acetate solution (one-fiftieth the strength given above), and the precipitate and filter returned to the precipitation flask. The object of precipitating the manganese in the presence of zinc chloride is to prevent the formation of lower or higher oxygen compounds of mangenese.

A solution of antimonious chloride (15 grammes of antimonious oxide dissolved in 300 c. c. of hydrochloric acid to the litre) is then added to the precipitate in the flask; it is added 5 c. c. at a time until, after being well shaken with the precipitate, the latter is no longer black, but brown; 25 c. c. of hydrochloric acid (·1·19 sp. gr.) are then added, as soon as the precipitate is completely dissolved, the whole is rinsed with 200 c. c. of water into a beaker and titrated with standard permanganate. In this titration the action of antimonious chloride on the permanganate is very rapid, and a color permanent for six seconds

indicates the end of the reaction, even though it may subsequently disappear, from the action of the hydrochloric acid on the permanganate. The solution before titration may be green or yellow from the presence of nickel, copper, cobalt or iron; of these cobalt alone makes the determination too high by one-half the amount of cobalt present.

The author recommends the use of carefully prepared pure manganese pyrophosphate for ascertaining the strength of permanganate solution. The salt is prepared by dissolving in water 40 grammes of crystallized manganese sulphate, and 60 grammes of crystallized sodium phosphate; mixing the solutions, adding hydrochloric acid until clear; then excess of ammonia, again clearing with the acid, filtering, diluting to a litre, and precipitating with ammonia. The precipitate is washed by decantation until it no longer gives the chlorine reaction, and then dissolved in dilute nitric acid, with addition of a little sulphurous acid to reduce manganese sesquioxide; ammonia is added in excess, then nitric acid until clear, and finally excess of ammonia, the precipitate being washed to the same extent as before. This precipitate on ignition gives the pyrophosphate, a portion of which is weighed off after having been recently ignited, dissolved in hydrochloric acid, evaporated over the water-bath, and the water-solution of the residue is titrated with permanganate as directed above. The permanganate solution is made by dissolving the purest salt obtainable, letting the solution become perfectly clear by long standing, and then decanting; it remains unchanged for many months in the dark. Only one specimen of steel—East Indian wootz-steel—was found to be free from manganese.—*Jour. Chem. Soc.*

Patinage of Locomotives.—Sig. P. Oppizzi finds that the diminutions of resistance which are not followed by an equal reduction in the motive force produce an acceleration in the rotative movement of the wheels, which cannot be wholly transformed into an acceleration of the locomotive, and therefore causes slipping. He has given some experimental formulæ which, although not so complete as desirable, show the importance of a more careful regard to the relation between the motive force and the adhesion of the wheels. This relation has been too much overlooked by engineers, who have sought to give increased pressure to the steam, and to work it under too great expansion in order to obtain some ideal economical advantage.—*Il Politecnico.* C.

Vessels of Steel.—Before the various recently discovered methods of manufacturing steel at a low cost were put into operation, it was thought that if the price of steel could only be reduced it would drive iron almost out of use. In a certain way this opinion has been confirmed, for steel is now put to services into which it never entered when the expense of its production was higher; but now that the constructor has it at his option to use either iron or steel, the merits of the latter for several classes of work are accepted less freely than they once were. Until within a short time it has been claimed that apart from cost, a steel ship would be in every way superior to an iron vessel, for as the same strength could be obtained with thinner plates and lighter frame, the hull would be more buoyant, while the enduring qualities of steel were known to be greater under ordinary conditions than those of iron, as in the case of rails. But although the change in the latter has been quite universal when the traffic has been sufficient to warrant it, the extra cost being quite balanced by their superior wear, within a year or two practical experiments have been made which prove in shipbuilding at least it would not be an unalloyed improvement. In the first place, it is found that there is a much greater diversity in the tensile strength of different steel plates than of iron ones, and hence the parts of a vessel might vary considerably in this respect. But the most important defect is found in the rapid corrosion of steel in salt water, and few shipbuilders, in receiving steel plates, could tell whether the metal was comparatively pure or not. Of course the thinner the plates the sooner the corrosion would be apparent, and no coating is known that would entirely prevent this, and yet in such collisions as the case of the "Vanguard" with the great German iron-clad, one might well wish for lighter and stronger vessels, such as steel ones would undoubtedly be. In the rapid development of the British navy a feature seems to be the employment of steel in the construction of ships of all sizes. Deck-plating is now made of it in all instances, as well as the ribs and beams. Steel is also making its appearance in the form of armor, iron plates faced with it having been lately adopted in the turrets of the "Inflexible," which the English hope may indeed carry out its name, thereby reducing the thickness of the plates from 18 to 16 inches, which diminishes the weight by many tons; but wonderful as are the English vessels for size and power, in the matter of guns to be used on them the Italians lead, and poor as that nation is, they still have the ambition to build their ships with armor which, like their guns, shall exceed the English nation.

Mance's Heliograph.—Devices for signaling, in many respects similar to the heliograph, have been in use for a very long period of time. We have a record of the employment of polished metal surfaces to flash the rays of the sun, and thus give warnings of one kind or another, which dates back as far as the Persian invasion of Greece. Immediately after the battle of Marathon, the defeated Persians were signaled by some one on the mountains near Athens, by means of reflected rays of the sun upon the polished surface of a shield, that the city would be put into their possession if they came there immediately with their fleet. Fortunately, in this instance, the signaling was seen by both sides, and the ready interpretation of it by the Greeks, and their speedy return to Athens, saved the city from falling into the hands of the enemy. In this case, the signaling must have been carried on over a space of about eighteen miles, and, with the rude appliances used from that time down to a very recent period, this was about as far as the system could be depended upon to work. But the instrument now in use, the Mance heliograph, is a great improvement on the old methods, for not only does it concentrate the sun's rays, but it flashes them with the utmost precision to any required spot, irrespective of the relative location of the sun. It is, moreover, provided with a finger-key, so that flashes may be made of long or short duration, in this way permitting the employment of the Morse telegraphic alphabet. Under favorable conditions, intercourse has been carried on through the medium of two of these instruments over an intermediate distance of nearly one hundred miles; and at several points occupied by the English army in Afghanistan, regular communication is maintained at distances of not less than fifty miles by heliographic signals. The instrument is admirably adapted for war service, as it weighs only about seven pounds, and can, without difficulty, be carried and worked by one man. Of course, in cloudy weather it is wholly useless, and for this reason can never entirely take the place of flags or field telegraphs; yet there are so many days in a year in which it can be used that it will be strange if it is not made use of in various parts of the world, for commercial as well as military purposes. It has already been proposed to establish a systematic telegraphic communication between various islands in the West Indies by the heliographic process; and we venture to think that before long it will be adopted as a means of signaling between vessels when at sea.

Organic Resistance to a Boiling Temperature.—Ch. Chamberland has found a microscopic organism which lives in nearly all liquid solutions of organic matter, provided that they have been previously neutralized by a solution of potash. It produces germs or spores which, when placed in neutral media, resist a boiling temperature for several hours. A temperature of about 115° (239° Fahr.) kills them very rapidly.—*Comptes Rendus.* C.

Distribution of Heat on the Sun's Surface.—Messieurs L. Cruis and J. O. LaCaille have made a series of observations upon the superficial heat of the sun at the imperial observatory of Rio Janeiro. The radiations from the northern hemisphere are more intense than those from the southern in ratios varying from 1·2 to 1·4, the mean radiation of the southern hemisphere being only three-fourths as great as that from the northern. The greatest radiation is only ·56 as great as it would be if there were no atmosphere; the total radiation is only ·22 as great; in other words, there is an atmospheric absorption of ·78. The observations completely confirm the general results which were obtained by Father Secchi, while they present some divergencies in the absolute values of the radiations.—*Comptes Rendus.* C.

Starch-like Granules in Eggs.—In 1866 M. C. d'Areste found some granules in the yolks of eggs which presented many characteristics of starch. Their existence was at first contested, but afterwards admitted, and various attempts were made to account for them. He has lately continued his investigations, and finds that the granules are insoluble in alcohol, ether, or any of the other common solvents of fatty matters. They are colored blue under the influence of any solution of iodine. Sulphuric acid decomposes them; but acetic acid does not affect them. The largest grains swell under the influence of potash or soda, and resume their primitive volume when placed in alcohol. When their form is very regular they act upon polarized light like grains of starch. They may be separated from the yolk by first hardening it in water of 75 or 80° (157 to 176°F.) so that the globules of the yolk are transformed into hexaedral prisms. These globules are first treated by ether, which dissolves the oil and a portion of the fatty matters, and then by absolute alcohol, which removes the rest of the fatty materials and constracts the albuminous substances, producing partial ruptures, from which the starchy globules escape.—*Comptes Rendus.* C.

International Canal.—The project of a canal between the Rhine and the Maas seems likely to be soon carried into execution. The city of Crefeld has already announced its readiness to appropriate 500,000 marks ($125,000) for the purpose, and it is thought that the German and Dutch governments will contribute the residue.—*Fortsch. der Zeit.*

C.

Another New Metal.—The services the spectroscope is capable of rendering to science become more and more evident daily, the latest proof of the fact being the discovery of a new metal called scandium. In some of the mines in Sweden and Norway small quantities of earthy minerals are found called gadolinite and euxenite, composed of oxides of very rare metals. The bulk of the substance is of a rose-color, arising from the presence of erbium, and is called erbine. At first it was supposed to be simply mixed with some earthy substances which rendered it impure, but not long ago M. Marignac discovered the presence of another metallic substance, which he called ytterbine, the oxide of ytterbium. However, great uncertainty existed as to the composition of these bodies, and M. Nilsen undertook a series of experiments on the subject. M. Berthelot, at the last meeting of the Academy of Sciences, gave an account of what had been done so far, the result being the discovery of a new metal, to which M. Nilsen has given the name of scandium, to indicate that it is of Scandinavian origin. Erbine is, as before mentioned, of a brilliant rose-color, while ytterbine is white. But the separation of the two substances can only be effected with extreme difficulty. The earth has to be dissolved in boiling nitric acid, and the ytterbine then precipitated by sulphuric acid; and M. Nilson found that the operation, repeated more than 20 times, did not completely separate the two bodies. When he had obtained a comparatively pure ytterbine he commenced an examination of it, and then he found that it gave absorption bands in the spectrum unknown to any substance previously examined. After repeated trials he became convinced that he was dealing with a metal never before suspected, and he continued his researches. He is unable to say at present what may be the chemical properties of the new body, as the quantity of material at his disposal was insufficient to allow him to isolate the metal. Nor can he decide as yet as to the place the new metal is to take among the older ones, but he considers that its properties differ materially from those of erbium and ytterbium, and that it should rank between tin and thorium, as the atomic weights of these two are 118 and 234, while he calculates that of scandium at from 160 to 180.

Reversal of Motion Without Gears or Belts.—In 1853, MM. Claparade, Roux and Delille attempted to produce opposite revolutions in two parallel arbors by means of a Watts parallelogram, but these experiments were not satisfactory. Charles Bourdon has lately introduced a contrivance which is based upon the two following theorems: 1. If two cranks, of any length and initial position, turn with the same angular velocity, the point which divides the line of variable length, which joins their extremeties at each instant, describes a straight line parallel to the bisectrix of the angle of the two cranks. 2. When the two cranks are equal, the projection of the joining line on the bisectrix preserves a constant length. By means of an ordinary slide, M. Bourdon compels the middle of the system to take a rectilinear movement. Then, by means of two reciprocating Peaucellier cells, or even without the use of cells, if one extremity of the crank is allowed a slight play, two arbors may be easily connected so as to turn in opposite directions and to avoid any dead point.—*Bull. de la Soc. d'Encour.*

C.

Prime Meridian.—The ancient geographers knew nothing west of the Fortunate or Canary Islands. Ptolemy started from that point to estimate longitude, going eastward to the extremity of the countries which were then known. According to his geography, Paris would have had a longitude of about 23½°. In 1682 the French geographers generally estimated the longitude at 20°, but some writers fixed upon 23½°, 22½° and 20½°. England subsequently adopted the meridian of St. Paul, in London, and afterwards Greenwich. France, in 1789, adopted the meridian of Paris. These examples have been followed by Holland, Spain, Portugal, Russia, United States, Chili and Brazil, each country adopting either its own capital or its principal observatory as the zero point of longitude. In order to remedy the confusion arising from these various meridians, M. de Chancourtois proposes to take the meridian of St. Michel, in the Azores, which agrees closely with that of Ptolemy and that of Mercator, and which seems to have other advantages, because it passes entirely through the ocean for one-half of its extent, and on the other half it only cuts the eastern extremity of Asia, thus separating pretty exactly the old and the new worlds. Bouthillier de Beaumont and E. Corlanbert propose an initial meridian ten degrees east of Paris, and that Italy and the United States should cede to the Republic of Science neutral stations for observatories upon that meridian.—*La Nature.*

C.

Physical Modifications of Starch. — M. F. Musculus finds that starchy matter may exist both in the colloid and in the crystalloid state. When colloid, it is soluble in water, saccharifiable by diastasic ferments, and diluted in boiling mineral acids, but it easily undergoes modifications which render it insoluble even in boiling water and unaffected by ferments and acids. Iodine gives it a blue color, while it colors the insoluble form red or yellow. In the crystalloid condition it can be obtained under the form of isolated crystals, which are easily dissolved in cold water; these crystals rapidly unite and then become less soluble. The crystalloid starch then undergoes the same modifications as the colloid; it remains, however, always soluble in water at a temperature of 50 or 60° (122 to 140°F.), and saccharifiable by ferments and acids. In isolated crystals it is not colored by iodine; in thin solutions it takes a red color; in concentrated solution a violet or blue color, according to the degree of concentration. It passes through parchment paper, although with difficulty.—*Comptes Rendus.*

C.

Improvements in Coating Mirrors.—The French Academy has awarded a prize of 2500 francs to M. Lenoir for improvements which secure to mirrors all the advantages of silvering, together with the qualities of amalgamation under conditions which preserve workmen from exposure to mercurial vapor. The glass, after being silvered by means of tartaric acid and ammoniacal nitrate of silver, is exposed to the action of a weak solution of double cyanide of mercury and potassium; there is thus formed a white and brilliant silver amalgam which adheres strongly to the glass. The operation is facilitated, and all the materials are economized, by sprinkling the glass at the moment when it is covered by the mercurial solution, with a very fine zinc powder, which precipitates the mercury and regulates the amalgamation. Mirrors which are thus prepared are free from the yellowish tint of ordinary silvered glass, and the amalgam is not easily affected by sulphurous emanations. The committee, in their report, also recount M. Lenoir's improvements in galvano-plastic processes, his discovery of an autographic telegraph, which reproduces writings or drawings with printer's ink, his new and ingenious methods for securing the synchronism of the transmitter and the receiver, and the well-merited reputation which he has acquired from his gas motor. — *Comptes Rendus.*

C.

Pre-historic Flax.—Prof. Heer has found that the flax which was cultivated by the inhabitants of the lake dwellings is of a different species from that which is now raised. It had smaller seeds and sent numerous stalks from the ground, while the variety which is now cultivated has only a single stem.—*Fortsch. der Zeit.* C.

Wear of Materials.—M. Lavoinne commends the St. Louis experiments which are described in the Mayor's message for 1878. Although they are too few to furnish practical results of great value, the principle is good and the mode of experimenting is so easy that it is desirable to use similar apparatus elsewhere for similar researches.—*Ann. des Ponts. et Chauss.* C.

Parchment Cotton.—Imitation woolen fabrics are manufactured in England from cotton which has been subjected to a process similar to the one which is employed in making parchment paper. The cotton is exposed for 24 hours in a mixture of one part of concentrated sulphuric acid, one part glycerine and three parts water, which is kept at a temperature of 17°C. (63·5°F.) The cotton is then pressed between glass rolls and washed until litmus paper shows no trace of acid.—*Indust. Blatt.* C.

Prize to Alexander Agassiz.—The Sevres prize of the French Academy has been awarded to Alexander Agassiz for his numerous and extensive researches in general embryology. The committee, in their report, state that these researches extend over a period of fifteen years, and that the results are noteworthy, not only for their scientific importance, but also for the persevering efforts which have led to them. They display great vigor in the observations, abundant sagacity in the comparisons, dignity and wise reserve in the inductions.—*Comptes Rendus.* C.

Temporary Magnetism of Nickel and Cobalt.—Henri Becquerel has been pursuing an extensive series of experiments upon the temporary magnetism developed in various specimens of nickel and cobalt as compared with that of iron. He finds that when bars of nickel, which are chemically pure, are employed, they give results very similar to those of soft iron. One very remarkable bar of nickel, which was probably porous, appeared to be a little more magnetic than iron. He found very little difference between the nickel and the cobalt. He proposes to follow these experiments by a special investigation of the permanent magnetism of the three metals.—*Comptes Rendus.* C.

New Material for Vases.—The weight and brittleness of terra cotta are great objections to its use in household utensils and ornaments. To avoid these objections, Messrs. David & Co. employ cotton pulp covered with a special composition, which contains a soluble varnish. Articles which are made with this material are very light and very strong.—*La Gaceta Industrial.* C.

African Travels.—Serpa Pinto has traversed the Zambese from the west to the east. The Lisbon Geographical Society has lately received the following despatch from him: "I am within six days of the Indian Ocean, on the eve of terminating my tour across Africa from the west coast. I have striven against hunger and thirst, wild beasts, savages, inundations and drought; I have happily surmounted all these obstacles. Works saved: twenty geographical charts, three volumes of important co-ordinates, meteorological studies, three volumes of drawings, a voluminous journal. I have lost many of my men. Complete study of the upper Zambese; seventy-two cataracts and rapids. Plan of the cataracts. Natives ferocious; constant wars."—*Comptes Rendus.* C.

Ethiopian Honey.—In subterannean cavities, in Ethiopia, a honey is found which is made without wax by an insect resembling a great mosquito; the natives call it *tazma*. M. A. Villiers gives the following analysis:

Water,	25·5
Levulose and glucose,	32·
Mannite,	3·
Dextrine,	27·9
Ash,	2·5
Impurities and loss,	9·1
	100·0

There is a small proportion of a bitter principle which has not been isolated, but which is not nitrogenous. The composition of this honey is similar to that of the mannas of Sinai and Kurdistan, which were formerly analyzed by M. Berthelot, that of the sugary matter in the leaves of the linden, analyzed by M. Boussengault, as well as that of ordinary honey. It differs from all these substances in the absence of cane sugar.—*Comptes Rendus.* C.

Proposed Artesian Well in Madrid.—Proposals have been issued for the speedy boring of an artesian well in the Spanish capital of sufficient capacity to give a minimum supply of 50 litres (11 galls.) of water per second. It is believed that this supply will be reached at a depth of not over 400 metres (437·45 yards). Many of the nobles and capitalists are much interested in the project, and it is thought that a company will soon be organized for carrying it into execution.—*La Gaceta Indust.* C.

Photographic Rifle.—M. Marey having expressed a wish for the invention of a photographic rifle which could take instantaneous views of birds in their flight, Capt. Eugene Vassel proposes a small dark rifle chamber of 35 milimetres (2·27 in.) interior diameter, surmounted by a proper level and sight. By means of Muybridge's, Janssen's or other contrivances for taking instantaneous pictures, he thinks that small views might be easily taken which could be subsequently enlarged. He also proposes a photographic revolver for taking a series of successive attitudes at a single operation.—*La Nature.* C.

Montyon Prize.—The Corliss engine at the French Exposition of 1878 consumed only one kilogramme (2·2 lbs.) of coal per horse-power per hour. A similar engine of 700 horse-power, constructed by M. Farcot, for the drainage at Asnières, consumes only six-tenths as much. M. Tresca, in recommending, on behalf of the committee of the French Academy, that the Montyon prize should be awarded to the inventor of this engine, stated three special advantages which it possessed: a form of construction which establishes a great firmness between the cylinder and the chief arbor, with the least consumption of material; the separation of the orifices of admission and emission, to the great advantage of the permanence of temperature in the steam at its entrance into the cylinder; and a system of distribution commanded by a central platform for the four openings by means of springs and cams, which secure the opening and closing of the orifices. While claiming for Cavé the principle of separation between the orifices and conduits of admission and escape, the committee consider that Corliss' applications of the principle, the precision of action and the economy of his engines entitled him to the Montyon prize of one thousand francs, and the Academy awarded the prize accordingly.—*Comptes Rendus.* C.

Molecular Light.—In continuing his researches upon "the fourth form of matter," Crooks has constructed an apparatus by the aid of which a great heat is produced when the focus of the rays, which are emitted from an aluminium cup, is deviated laterally by means of a magnet upon the walls of the glass tube. By making use of a moderately large hemisphere, and causing the negative focus to fall upon a piece of platinum-foil, the heat is raised to such a degree that the metal melts.—*Comptes Rendus.* C.

Russian Railway Schools.—There are twelve railway schools in Russia. The programmes include religious instruction, the Russian language, geography, history, mathematics, physics, mechanics, the applications of engineering, natural science, telegraphy, book-keeping, drawing, gymnastics and singing. During the past eight years instruction has been given to 4843 pupils, of ages from 13 to 21. The schools are supported by the railway companies, who pay an annual contribution of 35 fr. per kilometre [$11.26 per mile].—*Ann. des Ponts et Chauss.* C.

Poison Mushrooms.—Mr. J. A. Palmer has a paper on poisoning by mushrooms in the *Moniteur Scientifique.* He states that there are three different ways in which mushrooms may act as a poison. First, they may produce the effects of indigestible matter, as when the hard coriaceous species is eaten; and even the edible mushroom may cause a similar result, for when it is decomposing it gives off sulphurétted hydrogen gas in quantity sufficient to induce vomiting. Second, mushrooms may be gelatinous or acrid. Third, a subtle alkaloid, without smell or taste, is contained in some mushrooms, as, for instance, in the group of the Amanitæ, and is called amanitin. No antidote has yet been discovered for this poison, and to it most of the cases of death following the eating of mushrooms is due. It is at first slow in its action, but after the lapse of eight to fifteen hours, the patient experiences stupefaction, nausea and diarrhœa. Delirium follows, and then death. Mushrooms containing amanitin will impart poisonous properties to wholesome varieties, if both happen to be placed in the same vessel. The poison can be absorbed by the pores of the skin. Mr. Palmer carried in his hand some amanitæ wrapped up in paper, and, notwithstanding the protection which the wrapper should have afforded, he was seized with alarming symptoms.

Origin of Springs.—M. Zweifel combats the idea that springs owe their origin to rain water. He shows by the observations at many important stations that the annual evaporation is largely in excess of the annual rainfall, and that the earth, even in the most absorbent soils, is rarely moistened by the heaviest showers to a greater depth than 40 or 50 centimetres (15·75 to 19·69 in.). Air, however, under the pressure of fifteen pounds to the square inch, can penetrate to much greater depths, and if we suppose that the saturation of the subterraneous air varies in the same manner as that of the superficial layers, the condensation of its vapor may account for all subterranean waters. The rapid increase in the amount of precipitation as we approach the earth's surface lends some confirmation to these views.—*Bull. de la Soc. Indust.*

C.

Telephones without Diaphragms.—M. Ader reports some experiments confirmatory of the views of Du Moncel upon telephones without diaphragms. He has often observed that the reproduction of words and sounds, which are occasioned by the interruption of currents, can be made with these telephones with a different quality and upon a higher or lower pitch, according to the degree of tension which is given to the iron wire; but if the fundamental sound of the wire is muffled by holding it between the fingers the sounds which are reproduced become dull, a little more feeble, and always in the same tone. He concludes from his experiments that the sounds which are produced by a magnetic nucleus are probably the result of shortenings and lengthenings of the wire, determined by rapid magnetizing and de-magnetizing.—*Comptes Rendus.*

C.

Heraud's New Battery.—This is of simple construction and at the same time constant. The liquid used to excite it is a solution of ammonium chloride, and the depolarizing substance employed is mercurous chloride or calomel. In presence of zinc the ammonium chloride gives zinc chloride, ammonia and hydrogen. The hydrogen reduces the mercurous chloride, yielding metallic mercury and hydrochloric acid. This latter, uniting with the ammonia, gives ammonium chloride again. To prevent the formation of zinc oxychloride and its deposition on the zinc, one-tenth of ammonia solution is added to the solution of ammonium chloride. The zinc is suspended in the middle of the liquid, and the carbon, the positive electrode, is enclosed in a canvas bag. After working on a closed circuit for 248 days, the current retained two-thirds of its original strength.

C.

Acoustic Figures.—M. C. Decharme concludes his paper upon the acoustic vibrations of liquids by showing their correspondence with those of the Chladni plates. By experimenting upon circular plates alternately with sand and with water, he finds that the diametral, the concentric, and the compound systems are all equally well represented. The position, extent, and form of the different systems of peripheral internodes and the eccentric networks of different orders can be determined numerically beforehand for a plate of given dimensions.—*Comptes Rendus.* C.

Adulteration of Tea.—The adulteration of tea is as old as the tea trade itself. In the year 1783 the quantity of counterfeited tea which was imported into England was more than four million pounds, while the entire supply of genuine tea which was brought by the East India Company did not exceed six million pounds. The adulterations are of four kinds: 1, mineral substances for increasing the weight; 2, mineral coloring materials, which are very rare; 3, organic substances for increasing the weight (these generally consist of leaves of cheaper plants); 4, organic coloring matters and astringent substances. —*Dingler's Journal.* C.

Colored Photographs.—M. Cros prepares three photographic impressions of any object by sifting the light through solutions which will respectively arrest the green rays, the yellow rays, and the violet rays. The impression from which the green has been excluded, if developed under green light, will appear intensely green at points where the original was the greenest, and pale green or black at the green points where the green was mingled with other colors or was entirely absent. By combining the three negatives, and superposing the images by the help of reflecting prisms, he obtains an approximate solution of the fixation of colors by photography.—*La Nature.* C.

Natural Gelatinous Silicate.—During the summer of 1876, in boring a small tunnel, six kilometres (3·73 miles) east of Lausanne, the workmen found a gelatinous substance of a milky whiteness, resembling semi-liquid starch or soft fat. The unctuous feeling and fatty appearance of the substance led them to give it the name of mineral lard. Prof. Renevier has lately analyzed some specimens, which he finds to contain about four parts of silex, one part of alumina, one part of a mixture of lime magnesia and potash, and six parts of water. The elementary proportions are almost precisely the same as those of gmelinite and chabasite, minerals which have hitherto been found only in a crystalline state.—*Bull. de la Soc. Vaud.* C.

Martin's Steering Apparatus.—This seems to be very nearly the principle of the air-brakes on railway trains, and is novel in the substitution of a lever for the wheel and in the means of applying the steam power. This lever slides from side to side on a curved iron frame and is attached below the deck to a long rod, which in turn works a three-way valve. As the lever is moved it turns the valve, admitting steam to cylinders, the rudder chains being attached to the pistons working in these. When the lever is vertical steam is admitted equally to each, and the pressure is of course the same; but as it is moved, a percentage of steam is transferred from one cylinder to the other, either way, and the movement is so simple that a boy can readily regulate the whole apparatus for a large steamer. Under the present system of wheel steering, two, three, or more men, all travelers across the ocean have noticed, pulling at the wheel, especially in rough weather. Capt. Martin's invention proposes to draw the steam power from the ordinary boilers of the vessel, and in practice it is found that the rudder can be moved much quicker than at present, which is a great advantage, especially when there is danger from collision. With such an aid, which bids fair to supplant the old method—although that will be of course at hand in case it must be resorted to from any accident—and electric lights on the vessel, its path across the great ocean will be comparatively as free from danger as the advanced science of the day can possibly make it.

Book Notices.

An Elementary Course of Geometrical Drawing. By Geo. L. Vose, A.M. Boston: Lee & Sheppard, 1878. Oblong 4to.

The author gives a number of the more important problems in plane and solid geometrical drawing. He recommends a teacher, that the pupil may avoid falling into errors which are so hard to correct later. To those commencing the study of geometrical drawing it will prove a very good collection of carefully chosen examples. A short explanation of the projections of a point and a line, as well as the traces of a plane, in various positions, would have made the book more complete. P.

ELEMENTS OF PLANE AND SOLID FREEHAND GEOMETRICAL DRAWING AND SOME ELEMENTS OF GEOMETRICAL ORNAMENTAL DESIGN. By S. E. Warren, C. E. New York: J. Wiley & Sons, 1878. 8vo.

Professor Warren's books on descriptive geometry are so well known and so universally acknowledged as standard works that anything coming from his pen will be sure to be of interest. Both pupil and teacher will find many valuable hints in this little book. The method of describing ovals is a most satisfactory one, as it enables the designer to vary the shape of the curve almost at will. It is of particular value, as he rightly says, being a natural curve of intersection and not an arbitrarily assumed series of circular arcs as most commonly used. His remarks on geometrical symbolism are interesting and ingenious, but would scarcely be appreciated by many of those who might study the book to great advantage. P.

SPON'S ENCYCLOPÆDIA OF THE INDUSTRIAL ARTS, MANUFACTURES AND COMMERCIAL PRODUCTS. Nos. 1, 2, 3. (To be completed in 30 parts.) London and New York: E. & F. N. Spon. 8vo.

A new publication of this kind is most desirable, as many new processes have been brought to light which are evidently not to be found in similar works already existing. It is true, many of these have yearly supplements, which are evidently great additions, but after a given period it will be found of the first importance to republish the whole, and to place the novelties where they justly belong. As a general thing a dictionary of arts and manufactures gives but a general idea of the methods adopted, but how frequently the student desires details that are not there to be found, and we are glad to say that such has not been the case with Spon's Industrial Encyclopædia. In part 1st, for example, we notice calculations relating to the draught and supply of air, etc., in the manufacture of sulphuric acid, the importance of which is as great as the temperature, etc.; the steam required, the manner of regulating the same, plans and sections not only of the various apparatus made use of, but also in many cases of the buildings, showing their general arrangement. The subjects have been written by various authors, who seem to have been very well versed in the topics discussed. We are convinced that if this series be finished as commenced, it will be most valuable to those interested in chemical technology.

W.

TABLES OF THE PRINCIPAL SPEEDS OCCURRING IN MECHANICAL ENGINEERING, EXPRESSED IN METRES IN A SECOND. By P. Keerayeff, Chief Mechanic of the Obourhoff Steel Works, St. Petersburg. Translated by Lugius Kern, M. E., St. Petersburg. London and New York: E. & F. N. Spon. 16mo.

This very curious little work gives an indication of what is really a desirable collation of data for mechanical engineers. It is perhaps one-twentieth or so of the current information as to "speeds" needed for general reference; and the information it contains is hidden by imperfect translation, by the use of mètres per second in place of feet and inches per minute, and by acceptance of working speeds as absolute, when limits of speeds much above or far below those quoted are possible. Besides this it can be said that many speeds are given at rates to be considered rather as particular examples than as those of good practice. B.

SUPPLEMENT TO SPON'S DICTIONARY OF ENGINEERING (CIVIL, MECHANICAL, MILITARY AND NAVAL). Parts 1, 2, 3. To be completed in 15 monthly parts.

We have no Engineering Dictionary which is better known and has rendered greater service than the main work to which these three parts and those to come will form a supplement.

Care seems to have been taken, in many cases, to complete subjects heretofore somewhat neglected, not only by the addition of new devices, but also considerations of a technical nature that are of great interest.

We notice particularly in Part I, agricultural implements for hand and steam ploughing, etc., have been wisely selected, also various machines for the binding and reaping combined of a crop of wheat, etc.

In Part II, we take pleasure in noticing that the subject of belts and belting has been treated in a lengthy manner. The examples given, we are glad to see, are mostly American, these being mainly taken from our best authority, and to whom much credit should be given; but we regret to state that the initials of this gentleman's name are not correct, and should be J. H. Cooper and not T. Cooper as quoted, his valuable papers having appeared in the JOURNAL OF THE FRANKLIN INSTITUTE. W.

Franklin Institute.

HALL OF THE INSTITUTE, May 21st, 1879.

The stated meeting was called to order at 8 o'clock P. M., the President, Mr. William P. Tatham, in the chair.

There were present 106 members and 40 visitors.

The minutes of the last meeting were read and approved.

The Actuary presented the minutes of the Board of Managers, and reported that at the last meeting 29 persons were elected members of the Institute, and reported also the following donations to the Library:

Specifications and Drawings of American Patents, for December, 1878. From the Patent Office.

Postal and Commercial Intercourse between the United States and Central and South America, Washington.
From the Postmaster-General, Washington.

Direct export of Iron, Steel, etc., from Philadelphia to Foreign Countries in 1878.

Industries of Philadelphia, as shown by the Manufacturing Census of 1870. By L. Blodget. Philadelphia, 1877. From the author.

Laws of Patents of the United States. 1878.
From the Patent Office.

Notes sur les Paratonneres. Par M. Melsens.

L'Application du Rhé-electrometre aux Paratonneres des Télégraphes. Par M. Melsens.

Notice sur la coup de Fondre de la Gare d' Anvers du 10 Juillet, 1865. Par M. Melsens.
From the author, member of Royale Academy, Belgium.

Papers read before the Pi Eta Scientific Society. 1878–79. Rennselaer Polytechnic Institute, Troy, New York. From the Institute.

Annual Statements of Chief of Bureau of Statistics on the Commerce and Navigation of the United States for Fiscal Year ended June 30th, 1878. Part 2—Foreign Commerce.

Swedenborg's Works in 20 volumes.
From the Am. Swedenborg Print. & Pub. Soc., New York.

Annales des Ponts et Chaussées from 1865 to 1870 inclusive. January to June, 1871; March, 1873; November and December, 1877; January to September, 1878.

Indexes. 1866—1875 in 2 parts.

Etat de l'Eclairage et du Balisage des cotes de France, au 1 er Janvier, 1872. Paris.

Legislation Française des Chemins de fer et de la Télégraphie Electrique. Par M. Cotelle. Second edition. Vols. 1 and 2. Paris.

Annales des Mines. First Series, parts 1–4. Index to Third Series. Fifth Series, parts 1–6; Sixth Series, parts 1–6. Index to Sixth Series.

Rupport sur l' Amelioration Sanitaire et Agricole de la Dombes, 1859.

La Seine. Etudes hydrologiques régime de la pluie, des sources, etc. Par M. Belgrand. Paris, 1872. 2 volumes.

Enquette sur les moyens d' Assurer la Régularité et la sureté de l'Exportation sur les Chemins de fer. Paris, 1858.

Travaux publics des Etats Unis d'Amerique en 1870. Par M. Malézieux. Paris, 1873. 2 volumes.

Question des Houilles. Mission de M. De Ruolz en France et en Angletere. Vols. 1 and 2, text. Vol. 3, statistical atlas. Paris, 1872—1875.

Tramways et Chemins de fer sur routes. Par P. Challot. Paris, 1878. From the Minister of Public Works, France.

Traité des Machines à vapeur. Par Bataille et Julien. Paris, 1847–49. 2 volumes. From Fredk. Graff, Paris.

Annual Reports of the Various Officers and Standing Committees of the City of Allegheny for 1878.
From James Brown, Comptroller.

Betriebs-Einrichtungen auf Amerikanischen Eisenbahnen, etc. Von H. Bartels. Part 1. From W. Lorenz, Philadelphia.

Introduction a l'Atlas des Monuments de la Geographie. Par Feu M. Jomard. Paris, 1879. From the author.

Alamanaque de la Gacetta Industrial para 1879.
From the Gacetta.

Memorial Address upon the Character and Public Services of Morton McMichael. By J. W. Forney. Philadelphia, 1879.
From the author.

The following are from Mrs. E. K. Williams, Delaware Co., Pa.:

Slide Valve Practically Considered. By N. T. Burgh. Philadelphia, 1867.

Rudimentary Treatise on the Drainage of Towns and Buildings. By G. D. Dempsey. London.

Brief Treatise on United States Patents. By H. & C. Howson. Philadelphia.

Treatise on Water Works. By Samuel Hughes. London.

Catechism of the Steam Engine. By John Bourne. New York.

Practical Treatise on Heat. By Thomas Box. Philadelphia.

Ordnance Manual for use of the Officers of the U. S. Army. Second edition. Richmond.

Heat Considered as a Mode of Motion. By John Tyndall. New York.

Appleton's Dictionary of Machines, Mechanics, Engine-work and Engineering, in 2 volumes. New York.

Dictionary of Arts, Manufactures and Mines. By A. Ure. New York. 2 volumes.

Report of the Superintendent of Public Instruction of the Commonwealth of Pennsylvania.

Circuit Court of United States for the Eastern District of Penna. Locomotive Engine Safety Truck Co. *vs.* Pennsylvania R. R. Co. Philadelphia, 1877.

Physical Geography of the Sea. By M. F. Maury. New York and London.

Proceedings of the American Association for the Advancement of Science. Vols. 21—26.

Foundations and Concrete Works. By E. Dobson. London.

Strength of Materials. By William Kent. New York.

Chemical Technology. By Dr. F. Knapp. Vol. 2. Philadelphia.

Proceedings of Twenty-sixth Annual Meeting of Board Supervising Inspectors of Steam Vessels. Washington.

The High-pressure Steam Engine. By Dr. E. Alban. London.

Locomotive Engine, and Philadelphia's share in its Early Improvements. By Joseph Harrison, Jr. Philadelphia.

Manual of Engineering, Specifications and Contracts. By L. M. Haupt. Philadelphia.

Papers on Iron and Steel. By D. Mushet. London.

Reports of the United States Commissioners to the Paris Universal Exposition, 1867. By W. P. Blake. Washington.

Report on the Physiques and Hydraulics of the Mississippi Rivers. By Humphreys & Abbott. Philadelphia.

The following are from the Secretary of the Interior:

Report upon the Yellowstone National Park to the Secretary of the Interior. By P. W. Norris. Washington.

Reports on the Methods of Surveying the Public Domain to the Secretary of the Interior. By J. W. Powell. Washington.

Report on the Geographical and Geological Survey of the Rocky Mountain Region. By J. W. Powell. Washington.

Preliminary Report of the Field Work of the U. S. Geological and Geographical Survey of the Territories. Washington.

Bulletin of the U. S. Geological and Geographical Survey of the Territories. Vol. 4, No. 4. Washington.

Birds of Colorado Valley. By Elliott Coues. Part 1st. Washington, 1878.

Chart of the Geographical and Geological Survey of the Rocky Mountains. J. W. Powell, Geologist in charge.

Report of the Chief of the Bureau of Statistics on Commerce and Navigation, 1878. Part 1—Foreign Commerce.
From the Hon. Charles O'Neill, M. C., Washington.

Reports of the Commissioner of Education for 1870–71. Washington.

Special Report on Education in the District of Columbia. By Henry Barnard. Washington.

Circulars of Information of the Bureau of Education. Nos. 1, 2, and 5 of 1873; No. 2 of 1878, and No. 1 of 1879. Washington.
From the Commissioner of Education.

2d to 15th Reports of the Commissioners of Internal Revenue. Washington.

Reports of the Secretary of the Treasury on the State of the Finances for the year 1858, 1860, 1864, 1866, 1867, 1870–72, and 1874–75.

Reports of the Secretary of the Treasury on Commerce and Navigation of the U. S. for 1852, 1857, 1859 and 1864.
From the Secretary of the Treasury.

Reports of the Commissioners of General Lands for 1871–75 and 1877–78.

Maps of States of Illinois, Iowa, Mississippi, Missouri, Arkansas, Michigan, Indiana, Alabama, Ohio and Wisconsin.

Catalogues of the Publications of the U. S. Geological and Geographical Survey of Territories. F. V. Hayden. Washington.

Bulletin of the U. S. Entomological Commission No. 1. Washington.

Miscellaneous Publications. No. 1—Lists of Elevations. Washington. From the Secretary of the Interior.

1st to 5th Reports of Major C. B. Comstock upon the Improvements of the South Pass of the Mississippi River. Washington.
From the Chief of Engineers.

Bulletin de la Société Industrielle de Mulhouse. No. 140, 1857; September, 1860; November, 1861; January and March, 1862; August, 1865; July and August, 1872, and January, 1874.
From Mr. Henry Schlumberger, Guebwiller, Alsace, Germany.

Third to Tenth Annual Reports of the Provost of the Peabody Institute of Baltimore.

Discourse on Life and Character of George Peabody. By S. T. Wallis. Baltimore.

Proceedings on the Announcement of the Death of Hon. John P. Kennedy. Baltimore.

Address of the President and Report of the Treasurer and Provost to Trustees of Peabody Institute. Baltimore.

Peabody Institute, Baltimore. The Founders, Letters, etc.

Peabody Institute. Academy of Music and Instructions.

Annual Report of the Board of Commissioners of Public Schools. Baltimore. From P. R. Uhler, Librarian Peabody Institute.

Annual Report of Board of Commissioners of Public Schools. From the Commissioner.

Charter and By-Laws—Commencement Schools of Art and Design and Book-keeping—Maryland Institute. From the Institute, Baltimore.

Mr. Charles H. Roney made some remarks on Bituminous and Anthracite coals, coke, etc., and the percentage of phosphorus was exhibited by a table thrown upon the screen. He also read a letter of Dr. Charles M. Cresson to W. E. C. Coxe, Esq., relating to the subject.

Mr. Outerbridge explained his method for making diagrams for the lantern in an expeditious way.

The Secretary's report embraced Fleischmann's Improved Switch Faradic Battery; Rappleye's Automatic Governor Burner; Norcross' Furnace Governor; Strohm's Pipe Cleaner; Automatic Fruit Evaporator; Roney's Improved Electrical Pencil; Electrical Clock; Air-tight Refuse Can; Sash Opener and Closer, and the Mackinnon Fountain Pen, the iridium ring of which was exhibited with the micro-megascope on the screen.

Mr. Bingham explained his pantographic chart for the lantern, which is beautifully colored, and well adapted to give a clear idea of the various geological periods, and the life which existed in those times.

The Secretary read a few remarks on Cowper's Writing Telegraph, Electric Lighting, and Practical Education.

On motion, the meeting adjourned.

ISAAC NORRIS, M.D., *Secretary pro tem.*

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